

# 2018

## Summer Meeting



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Booth 25

Lunch and Learn  
Meeting Room 16  
12:00 - 1:00 PM  
July 30, 2018



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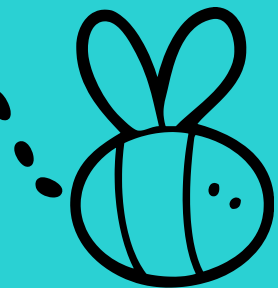
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# First time at a national AAPT Meeting?

Welcome! We have activities planned for you throughout  
the meeting.



## **First-Timer's Gathering:**

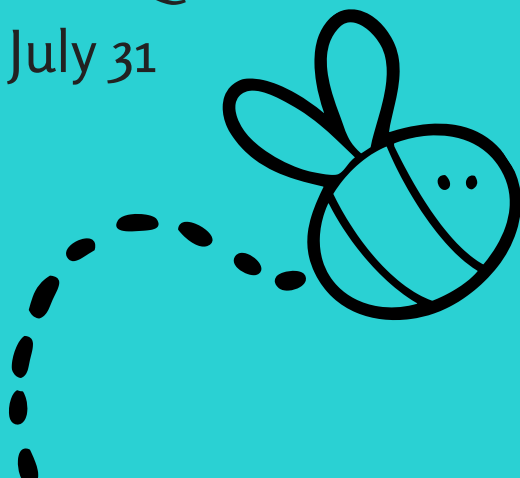
Meet other newbies over breakfast and check out what  
resources AAPT has to support you from 7:00-8:30 AM  
on Monday, July 30 in Congressional Ballroom B

## **Early Career Speed Networking Event:**

Meet experienced faculty and teachers from 12:00-1:30  
on Monday, July 30 in Penn Quarter

## **First Timer & Early Career Professional Social:**

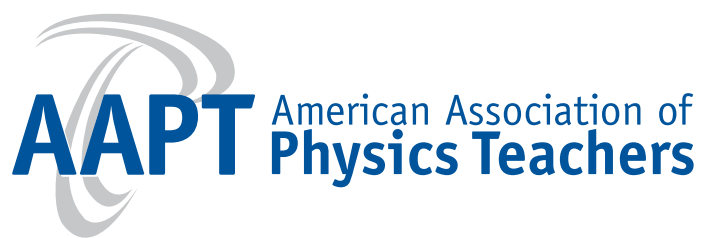
Join us for lunch at City Tap House Penn Quarter from  
12:00 - 1:30 on Tuesday, July 31





# Washington, DC July 28–August 1, 2018

Renaissance Washington, DC Hotel  
and Washington Marriott Marquis



**American Association of Physics Teachers**

One Physics Ellipse  
College Park, MD 20740

301-209-3311  
[www.aapt.org](http://www.aapt.org)

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## Thank You to AAPT's Sustaining Members

*The American Association of Physics Teachers is extremely grateful to the following companies who have generously supported AAPT over the years:*

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### WiFi code at Renaissance Hotel

**Network:** Renaissance\_Conference  
**Password:** SM2018

### Contact:

Meeting Registration Desk: 301-209-3340

## Special Thanks

AAPT wishes to thank the following persons for their dedication and selfless contributions to the Summer Meeting:

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Daniel MacIsaac	Sherry L Savrda
	Chandralekha Singh
	Changgong Zhou

### George Washington University:

Bill Briscoe, Leah Kochenderfer, and Samantha Lumpkin

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AAPT Associate Executive Officer

## Facebook/Twitter at Meeting

We will be posting updates to Facebook and Twitter prior to and during the meeting to keep you in the know! Participate in the conversation on Twitter by following us at [twitter.com/AAPTHQ](https://twitter.com/AAPTHQ) or search the hashtag [#aaptsm18](https://twitter.com/hashtag/aaptsm18). We will also be posting any changes to the schedule, cancellations, and other announcements during the meeting via both Twitter and Facebook. Visit our Pinterest page for suggestions of places to go and things to do in the Cincinnati area. We look forward to connecting with you!

**Facebook:** [facebook.com/AAPTHQ](https://facebook.com/AAPTHQ)

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# Committee Meetings

All interested attendees are invited and encouraged to attend the Committee meetings with asterisks (\*).

## Saturday, July 28

Nominating Committee I	6–7:30 p.m.	Mount Vernon Square B
Board of Directors I	6–9 p.m.	Mount Vernon Square A

## Sunday, July 29

Meetings Committee	8–10:15 a.m.	Mount Vernon Square B
Publications Committee	8–10 a.m.	Mount Vernon Square A
Board of Directors II	10:30 a.m.–4 p.m.	Mount Vernon Square A
Section Officers and Representatives	5–6 p.m.	Meeting Room 10/11
Executive Programs Committee	5–6 p.m.	Mount Vernon Square B
Programs I	6–7 p.m.	Meeting Room 8/9

## Monday, July 30

Interests of Senior Physicists Committee *	7–8:30 a.m.	Meeting Room 13
Teacher Preparation Committee *	7–8:30 a.m.	Meeting Room 7
Diversity in Physics Committee *	7–8:30 a.m.	Meeting Room 15
Science Education for the Public *	7–8:30 a.m.	Meeting Room 6
Physics in Undergraduate Education *	7–8:30 a.m.	Meeting Room 12
Physics in Pre-High School Education *	7–8:30 a.m.	Meeting Room 2
PIRA Committee *	7–8:30 a.m.	Meeting Room 16
PERLOC	7–8:30 a.m.	Marriott Marquis - Holly Room
Apparatus Committee *	12–1:30 p.m.	Meeting Room 8/9
Professional Concerns Committee *	12–1:30 p.m.	Meeting Room 14
International Physics Education *	12–1:30 p.m.	Meeting Room 5
Modern Physics Committee *	12–1:30 p.m.	Meeting Room 6
Awards Committee I (closed)	12–1:30 p.m.	Meeting Room 13
Research in Physics Education *	7–8:30 p.m.	Meeting Room 2
Physics in High Schools *	7–8:30 p.m.	Mount Vernon Square A
Laboratories Committee *	7–8:30 p.m.	Meeting Room 15
History and Philosophy of Physics *	7–8:30 p.m.	Meeting Room 6
Graduate Education in Physics *	7–8:30 p.m.	Meeting Room 16

## Tuesday, July 31

Physics Bowl Advisory Committee	7–8 a.m.	Meeting Room 7
PTRA Oversight Committee	7–8:30 a.m.	Meeting Room 5
Review Board	7–8:30 a.m.	Meeting Room 6
Town Hall with AAPT President *	12–1 p.m.	Mount Vernon Square B
PERTG Town Hall *	12–1:30 p.m.	Mount Vernon Square A
ALPhA Committee *	12–1:30 p.m.	Meeting Room 6
Physics in Two-Year Colleges Committee *	12–1:30 p.m.	Meeting Room 10/11
Space Science and Astronomy *	12–1:30 p.m.	Meeting Room 5
Educational Technologies Committee *	12–1:30 p.m.	Meeting Room 14
Women in Physics Committee *	12–1:30 p.m.	Meeting Room 8/9

## Wednesday, August 1

Programs II	7–8:30 a.m.	Congressional Ballroom B
Governance Structure Committee	7–8 a.m.	Meeting Room 7
Venture/Bauder Fund Committee	7–8 a.m.	Meeting Room 6
Membership and Benefits Committee	9:30–10:30 a.m.	Meeting Room 6
Papersort Orientation	1–1:30 p.m.	Meeting Room 7
Nominating Committee II	3–4:30 p.m.	Meeting Room 7
Board of Directors III	3–5:30 p.m.	Meeting Room 6



# Awards at 2018 AAPT Summer Meeting



**Bradley S. Ambrose**  
Grand Valley State University, Allendale, MI

*We Teach More Than  
Physics*

**Monday, July 30**  
**11:00 a.m.–12:00 p.m.**  
**Renaissance Ballroom**

## David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching

The 2018 David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching winner is Bradley S. Ambrose. John Wiley & Sons is the principal source of funding for this award, through its donation to the AAPT. Ambrose earned his BS in Physics at Yale University. Both his MS and PhD in Physics are from the University of Washington. Since 2013 he has served as Professor of Physics at Grand Valley State University in Allendale, Michigan.

The physics department at Grand Valley State University (GVSU) offers a BS in physics, as well as a few graduate courses in support of an M.Ed. During his time at GVSU, Ambrose has taught a variety of courses. The courses for teachers have long been taught in an inquiry-based style, but he has incorporated inquiry-based components into all of his other courses as well. His approach is student-centered, actively engaging the students in the learning process and empowering students to take the next step on their own. He is a master at asking questions to stimulate student learning, helping students solve problems themselves rather than just telling them the answers. Students and colleagues alike rate his teaching as excellent, as evidenced by his being selected for one of several campus-wide teaching awards in 2006 as well as GVSU's Outstanding Teacher Award in 2014.

He is also an exceptionally reflective teacher committed to making changes in order to enhance student learning and uses his expertise in physics education research (PER) to develop many course materials. He worked with a team of colleagues during the summer of 2000 to revise the GVSU introductory labs from a “cookbook” approach to an inquiry-based one. More recently, he collaborated with colleagues nationwide on an NSF-CCLI grant to develop a series of tutorials in intermediate mechanics to build students' abilities to understand multi-step processes and better connect calculations to concepts. The resulting Intermediate Mechanics Tutorials have had a remarkable impact through workshops presented to college faculty from across the nation.

Ambrose has worked with numerous GVSU physics majors on independent research projects, always to great benefit. Many of the students with whom he's worked have gone on to high school teaching careers or graduate studies in PER, where his circle of influence is still expanding as his former students teach the next generation.

*Established as the Excellence in Undergraduate Teaching Award in 1993; it was renamed and substantially endowed in 2010 by John Wiley & Sons. Named for David Halliday and Robert Resnick, authors of a very successful college-level textbook in introductory physics, the award recognizes outstanding achievement in teaching undergraduate physics.*



**Frank Noschese**  
John Jay High School,  
Cross River, NY

*#iTeachPhysics – Can  
Social Media Make Us  
Better Educators?*

**Monday, July 30**  
**11:00 a.m. –12:00 p.m.**  
**Renaissance Ballroom**

## Paul W. Zitzewitz Award for Excellence in K-12 Physics Teaching

The 2018 Paul Zitzewitz Excellence in Pre-College Physics Teaching Award winner is **Frank Noschese**, a physics teacher from John Jay High School, Cross River, NY. This award is in recognition of contributions to pre-college physics teaching and awardees are chosen for their extraordinary accomplishments in communicating the excitement of physics to their students.

Educated at Cornell University with a BA in Physics and an MAT in Science and Mathematics Education, Noschese is an inspiration for hundreds of physics teachers across the world. His very popular teaching blog, ActionReaction, is a treasure trove of excellent teaching ideas, and lessons that are useful for both novice and experienced teachers. His ideas have had a tremendous influence on the larger teaching community. For example, his Noschese 180 teaching blog, which he started by taking one photograph related to his teaching each day, and posting it with a short caption turned out to be incredibly powerful—these short reflections shared tremendous teaching ideas. Many of these ideas were taken up by physics teachers around the world, and the blog became a powerful tool for professional growth for dozens of teachers.

He is a member of the New York State Master Teacher Program which fosters collaboration among New York's outstanding STEM educators and offers high-quality professional learning. He was given the 2011 Presidential Award for Excellence in Mathematics and Science Teaching. In 2017 he received an AAPT Fellows Award.

Noschese has been incredibly active in engaging larger conversations about teaching pedagogy. He is outspoken defender of inquiry learning and the thoughtful use of technology. His post explaining how using \$2 whiteboards made from tile board can be powerful tools for dialogue and collaboration in class, even more than \$2000 interactive whiteboards won an Edublogs award for the most influential blog post of 2010. In addition to many sectional AAPT invited talks and a TEDxNYED talk, Noschese has been featured on numerous news programs, including MSNBC discussing the power of actively engaging students in inquiry. In all of his communication and advocacy, Noschese is a positive voice for the pivotal role of the teacher in the classroom.

*Established as the Excellence in Pre-College Teaching Award in 1993 then renamed and endowed in 2010 by Paul W. and Barbara S. Zitzewitz, the Paul W. Zitzewitz Award for Excellence in Pre-College Physics Teaching recognizes outstanding achievement in teaching pre-college physics.*



## Robert A. Millikan Medal 2018

**Kyle Forinash** is the Robert A. Millikan Medal awardee for 2018. Forinash is emeritus professor of physics at Indiana University Southeast, New Albany, IN. In nominating him for this honor his colleagues noted his remarkable career as a physics educator with an interest in societal issues, as a department chair who has shaped the curriculum at his university, and as an author.

After receiving his BS from the University of Georgia, Forinash worked as a physics teacher with the Peace Corps in Ghana. He completed his PhD at the University of Clemson while he worked as a Teaching Assistant. Before taking a position at Indiana University Southeast in 1985 he was Visiting Assistant Professor at East Tennessee State University. Forinash was Coordinator of Physics at Indiana University Southeast for 32 years. During this time, he was a Fulbright Scholar in Argentina, a visiting scientist at Los Alamos, and the author of a BA degree program with a physics major at IUS.

He has produced two high-quality interactive electronic books which are available from the AAPT ComPADRE website. *Sound: An Interactive eBook* is an introduction to the physics of sound and “Waves: An Interactive Tutorial” includes advanced material on waves, nonlinear waves and solitons. Waves received two awards for online materials: the Multimedia in Physics Teaching and Learning “MPTL Excellence Award for a Multimedia Resource” (2013); and the Multimedia Educational Resource for Learning and On-line Teaching, “Award for Exemplary Online Learning Resources –MERLOT Classics 2014”. His most recent book, *Physics and the Environment*, was published by IOP Press in 2017.

In addition to writing texts, Forinash’s leadership and creativity as a teacher show in innumerable other activities and accomplishments. In addition to authoring and implementing a BA degree in physics, he was also co-author of the recently approved BA and BS degrees in Sustainability and Regeneration at IUS. He is also the author of more than 30 peer-reviewed articles (10 with student co-authors) in non-linear physics, physics pedagogy, and other topics.



**Kyle Forinash**  
Indiana Univ. Southeast  
New Albany, IN

*Breaking Out of the  
Physics Silo*

**Tuesday, July 31**  
**10:30 a.m.–12 p.m.**  
**Renaissance Ballroom**

## John W. Layman and John L. Hubisz Remembrance

*Speakers: Aaron Titus, for John Hubisz*

*Jack Hehn, for John Layman*



*The Robert A. Millikan Medal recognizes those who have made notable and intellectually creative contributions to the teaching of physics. The recipient delivers an address at an AAPT Summer Meeting and receives a monetary award, the Millikan Medal, an Award Certificate, and travel expenses to the meeting. The award was established by AAPT in 1962.*

## Klopsteg Memorial Lecture Award 2018

**Clifford Victor Johnson**, University of Southern California, Los Angeles, is the 2018 recipient of the Klopsteg Memorial Lecture Award. Johnson graduated with a Bachelor of Science in Physics from Imperial College, London, in 1989 and he completed his PhD in Physics at the University of Southampton in 1992. He is a theoretical physicist and professor at the Department of Physics and Astronomy of the University of Southern California. He previously worked as a postdoctoral researcher at the Kavli Institute for Theoretical Physics at the University of California, Santa Barbara, and at the Institute for Advanced Study, Princeton, and held professorships at the University of Durham, and the University of Kentucky. He received a National Science Foundation CAREER Award in 1997. In 2005 he received the Maxwell Medal and Prize for theoretical physics from the Institute of Physics, “For his outstanding contribution to string theory, quantum gravity and its interface with strongly coupled field theory; in particular for his work on understanding the censorship of singularities, and the thermodynamic properties, of quantum space-time.” In 2005, the *Journal of Blacks in Higher Education* listed Johnson as the most highly cited black professor of mathematics or a related field at an American university or college. In 2015 he was awarded a Simons Research Fellowship. His colleagues observe that Johnson “is a truly outstanding scientist and teacher in many respects. His field of expertise is theoretical high energy physics, with an emphasis on string theory, gravity, gauge theory and M-theory. In his current research, he is applying insights gained from mappings between gravity and field theory to tackle some of the most challenging interacting many-body problems. He has authored a very well received textbook on D-branes published in 2003 by Cambridge University Press.



**Clifford V. Johnson**  
University of Southern  
California, Los Angeles

*Black Holes and Time  
Travel in Your Everyday  
Life*

**Wednesday, August 1**  
**8:30–9:30 a.m.**  
**Renaissance Ballroom**



*Named for Paul E. Klopsteg, a principal founder, a former AAPT President, and a long-time member of AAPT, the Klopsteg Memorial Lecture Award recognizes outstanding communication of the excitement of contemporary physics to the general public. The recipient delivers the Klopsteg Lecture at an AAPT Summer Meeting on a topic of current significance and at a level suitable for a non-specialist audience and receives a monetary award, an Award Certificate, and travel expenses to the meeting. The award was established in 1990.*

July 28–August 1, 2018

# Homer L. Dodge Citations for Distinguished Service to AAPT

Tuesday, July 31 • 10:30 a.m.–12 p.m. • Renaissance Ballroom



Ximena C. Cid

## Ximena C. Cid

**Ximena C. Cid**, Assistant Professor, Department of Physics, California State University, Dominguez Hills, CA, will receive the association's Homer L. Dodge Citation for Distinguished Service to AAPT, during the 2018 Summer Meeting in Washington, DC. Cid got her BA in Astrophysics at the University of California, Berkeley and her MS and PhD in Physics and Applied Physics at the University of Texas, Arlington. While in graduate school she switched her field of focus from Space Physics to Physics Education Research (PER). In switching to PER her national societies and colleagues also started switching. She found like-minded people in AAPT and STEM education communities. She is currently serving as a friend of the Committee on Diversity and has organized many sessions for AAPT over the years on diversity issues as well as cognitive load and spatial reasoning issues.



Jose D'Arruda

## Jose D'Arruda

**DuanJose D'Arruda**, Pembroke Professor of Physics at the University of North Carolina Pembroke, earned his BS in Physics and Mathematics at the University of Massachusetts, Lowell. His MS and PhD in Physics are from the University of Delaware. A member of AAPT since 1975, D'Arruda has been active in the North Carolina Section. He served as Section Representative (2003-2006) and was elected to the Presidential Chain in 2006, serving for three years. He has been a leader in physics education, working at a regional campus serving in one of the poorest areas of the state with a high percentage of Lumbee Indians. His service to AAPT includes membership on the Committee on Minorities in Physics (2000-2002), articles published in *The Physics Teacher* and *American Journal of Physics*, and presentations at numerous North Carolina Section meetings and AAPT national meetings.



Joy Elaine Gwinn

## Joy Elaine Gwinn

**Joy Elaine Gwinn**, Shenandoah High School Chemistry and Physics Teacher, earned her BS in Chemistry at West Texas A&M University and her Masters of Art in Physics Education at Ball State University. She started her career at Amarillo Independent School District (Amarillo, TX), as a Middle School Science & Math Teacher then moved on as a Physics and Chemistry Teacher at Canyon High School (Canyon, TX), teaching there for 12 years. Elaine currently teaches Physics and Chemistry at Shenandoah High School (Middletown, Indiana). An active member of AAPT since 2006, Gwinn has been an active member of the Indiana Section. She served as Indiana Section Representative from 2010-2017. The Section Representatives elected her as their representative to the AAPT Executive Board in 2013 and she served as the Vice Chair of Section Representatives before moving into the role of Chair of Section Representatives in 2015.



Warren W. Hein

## Warren W. Hein

**Warren Hein**, Adjunct Professor of Physics at Kettering University in Flint, Michigan, served as both the Associate Executive Office (AEO) and Executive Officer for AAPT prior to his retirement in 2010. His service to AAPT and the physics community stretches well beyond his duties when he was in these positions with AAPT. Hein had been an outstanding faculty member for many years before he came to the national office as AEO. He was department chair, SPS advisor, recognized for his outstanding service at his university both for his teaching and for his service. Hein was a founding member of the South Dakota Section of AAPT and served as a section officer for many years. He has served the AAPT in a variety of ways after retiring as the EO of AAPT. He has worked with the PTRAs, served on New Faculty Workshop and PhysTEC Noyce Advisory committees and is chairing The Barbara Lotze Scholarship for Future Teachers Committee.



David P. Jackson

## David P. Jackson

**David Jackson** is Associate Professor of Physics, Dickinson College in Carlisle, Pennsylvania. A member of AAPT since 1994, he served as Editor of the *American Journal of Physics* (AJP) from September 2011 through August 2017, and currently serves as Video Abstracts Editor for the journal. His role as editor included service on the AAPT Board of Directors and the Publications Committee. From 2001 through 2004 he was a member of the AAPT Committee on Science Education for the Public. After receiving his Ph.D. in physics from Princeton University in 1994, he has held faculty positions at Santa Clara University and Dickinson College, including a term as Chair of the Dickinson Department of Physics and Astronomy from 2006-2009. While serving as *AJP* editor, an open-access policy was developed and instituted, the journal focused on more educationally-oriented articles, and a video abstract option was initiated.

Read more about the awardees at [www.aapt.org/about](http://www.aapt.org/about)

*The Homer L. Dodge Citation for Distinguished Service to AAPT was established in 1953, was renamed in 2012 to recognize the foundational service and contributions of Homer Levi Dodge, AAPT's first president. The Homer L. Dodge Citation for Distinguished Service to AAPT recognizes AAPT members for their exceptional contributions to the association at the national, section, or local level.*



## Plenary – A Conversation with Shirley Malcom

In this plenary session we have invited four members of the diverse AAPT community to participate in a discussion with Dr. Malcom. Shirley Malcom is Head of Education and Human Resources Programs of the American Association for the Advancement of Science (AAAS). The directorate includes AAAS programs in education, activities for under-represented groups, and public understanding of science and technology.

AAPT members participating in this conversation represent students, high school teachers, two year college faculty, and four year college and university faculty. Representatives from each group will ask Dr. Malcom pressing questions from their unique perspectives about the state of science education. In this setting we leverage the expertise of Dr. Malcom, as well as the expertise of AAPT members, in developing a better understanding of the science education landscape.

### Participants in the conversation:

*Shirley Malcom*, Director, Education and Human Resources Programs (EHR) American Association for the Advancement of Science (AAAS)

**Facilitator:** *Bethany Johns*, American Institute of Physics

**Student representative:** *Eleanor Hook*, Rhodes College

**High School representative:** *Alice Flarend*, Bellwood-Antis High School

**Two-Year College representative:** *Arlisa Richardson*, Chandler-Gilbert Community College Four Year College

**Four Year College and University representative:** *Scott Franklin*, Rochester Institute of Technology



Shirley Malcom

**Monday, July 30**

**4–5 p.m.**

**Renaissance Ballroom**

## Dispatch from the Front Lines: Confessions of a Science Teacher, Researcher and Government Bureaucrat

*by David W. Cash*

David W. Cash is the Dean of the John W. McCormack Graduate School of Policy and Global Studies at UMass Boston and a founding Dean of the Sustainable Solutions Lab. He has spent his career as researcher, teacher and government official trying to understand and better harness scientific knowledge to solve pressing policy challenges.

From 2004-2015, he worked in senior positions in Massachusetts state government in catalytic roles, helping to transform the commonwealth's energy and environmental policy and regulatory landscape. His job history includes being a commissioner at both the Department of Environmental Protection and Department of Public Utilities, and Undersecretary of Policy at the Executive Office of Energy and Environmental Affairs. In these roles, he helped develop and implement nation-leading science-based environmental, climate, and clean energy programs; innovative renewable energy and grid modernization efforts; and the Regional Greenhouse Gas Initiative—the nation's first CO<sub>2</sub> cap-and-trade program.

He earned a PhD in public policy from Harvard University, concentrating in environment and natural resources. He also completed an MAT in science education from Lewis & Clark College and a BS in biology from Yale. With a background in science, he taught middle and high school biology, chemistry, physics and earth science in public schools for four years.



**David W. Cash**  
John W. McCormack  
Graduate School of  
Policy and Global  
Studies,  
UMass Boston

**Tuesday, July 31**

**4–5 p.m.**

**Renaissance Ballroom**



Steven Rolston  
University of Maryland

## APS Plenary – The Coming Quantum Revolution

Dr. Steven Rolston received his BS in 1980 from Wesleyan University and his Ph.D. in nuclear physics in 1986 from SUNY Stony Brook. Following post-docs at the Univ. of Washington and Harvard, he joined the research staff at the National Institute of Standards and Technology in 1988. He moved to the faculty of the Physics Department at the University of Maryland in 2003, and is currently the Chair of the department. He was recently the Co-Director of the Joint Quantum Institute and was the Chair of the APS Division of Atomic, Molecular, and Optical Physics. His research interests include laser cooling and trapping, Bose Einstein condensation, optical lattices, quantum simulation and communication, and ultracold plasmas and Rydberg gases. He is a Fellow of the American Physical Society, the Optical Society of America, and the American Association for the Advancement of Science.



Wednesday, August 1  
11 a.m.–12:30 p.m  
Renaissance Ballroom



Evangeline J. Downie  
George Washington  
University

## APS Plenary – The Proton Radius Puzzle

The Proton Radius Puzzle is the difference between the radius of the proton when measured with electrons, and that measured with muons. Its potential resolutions could be very exciting, include beyond-standard-model physics. The puzzle has resulted in several papers in Science and Nature, and much popular media interest. It began in 2010 with an ultra-precise radius measurement by the CREMA collaboration using muonic hydrogen, which produced a proton radius result roughly 7 standard deviations away from the accepted value. This caused a flurry of theory development, new experiments, and much thought and discussion. The radius puzzle remains unresolved to this day, with many new experiments proposed and under development and hotly debated theories. We will give an overview of the Puzzle, its potential implications and resolutions, and an overview of the ongoing experimental efforts. to understand the discrepancy in a quantity of relevance for many areas of Physics.

## Seminars/Workshops from Sherry Marts of S\*Marts Consulting:

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- Three steps to end harassment and bullying at meetings & conferences
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- |   |                 |                           |
|---|-----------------|---------------------------|
| •SMarts Workshop: <i>Ally Skills Training</i>                         | 1:30–3:30 p.m.  | Monday, Meeting Room 7    |
| •SMarts Workshop: <i>Harassment Resistance and Bystander Training</i> | 1:30–3:30 p.m.  | Tuesday, Meeting Room 7   |
| •SMarts Workshop: <i>Q&amp;A on Diversity and Inclusion</i>           | 9:30–11:00 a.m. | Wednesday, Meeting Room 7 |

## AAPT Publications

**Booth #21**  
One Physics Ellipse  
College Park, MD 20740  
301-209-3300, [www.aapt.org](http://www.aapt.org)

Drop by for information on how you can become part of the AAPT Publications program. Learn why you should submit articles for publication, consider becoming a reviewer, and make sure your physics department subscribes to *American Journal of Physics* and *The Physics Teacher*. It is rumored that it may be possible to catch up with journal editors and other members of the Publications Committee during your visit. If you are an online only member, you'll get a chance to see the print copies and reconsider your choice. If you aren't yet an AAPT member we will do our best to help you decide which option is best for you.

## AIP/AAPT - Policy and Advocacy

**Booth #36**  
AIP Government Relations  
One Physics Ellipse  
College Park, MD 20740, [www.aip.org](http://www.aip.org)

Congress must hear from you, their constituents, about the importance of science and education. Increasing the quality of science education is critical to helping the nation strengthen its global competitiveness by preparing a workforce for the 21st century. Visit us at the AAPT exhibit hall to learn more about how you can be involved in science advocacy and policy at the state and federal level. The table will be staffed with a variety of individuals with different types of expertise to help you think about and engage in these efforts. This interactive table is also an opportunity for us to learn how we can serve you better in doing this important work.

## Albert Einstein Distinguished Educator Fellowship Program

**Booth #6**  
Arlington, VA 22306  
865-320-2467  
[Science.energy.gov/wdts/einstein](http://Science.energy.gov/wdts/einstein)

The Albert Einstein Distinguished Educator Fellowship (AEF) Program provides a unique opportunity for accomplished K-12 educators in the fields of science, technology, engineering, and mathematics (STEM) to serve in the national education arena. Fellows spend eleven months in Federal agencies or U.S. Congressional offices, applying their extensive knowledge and classroom experiences to national education programs and/or education policy efforts. During their time as fellows, they engage in projects of interest to their host offices and themselves, such as:

- Designing/implementing national STEM education programs
- Drafting legislation to improve K-12 STEM education
- Evaluating national STEM programs centered on school reform
- Designing online learning tools for students and teachers

## Allied Powers LLC

**Booth #8**  
9255 W. Russell Rd. #177  
Las Vegas, NV 89148  
702-427-5489  
[eMP10.com](http://eMP10.com)

We provide the latest technology in portable TENS and EMS devices, including wireless devices. They're compact, easy to use and approved by the Food and Drug Administration (FDA) as Class II Medical Devices.

## American Association of Physics Teachers

**Booth #20**  
One Physics Ellipse  
College Park, MD 20740  
301-209-3300  
[www.aapt.org](http://www.aapt.org)

Welcome to Washington, DC! Join us at the AAPT booth to spin our prize wheel for your chance to win some free prizes. This year try out our interactive demos based on lesson plans created from *The Physics Teacher!* We will also have a large wide-variety selection of educational resources available including resources to support teaching including our popular Physics in 21st Century Science Standards: The Role of Physics in the NGSS booklet.

## American Institute of Physics

**Booth #37**  
One Physics Ellipse  
College Park, MD 20740  
[www.aip.org](http://www.aip.org)

The Statistical Research Center at AIP is your source for data on employment and education in physics, astronomy, and other physical sciences. We also provide survey, analysis, and evaluation services on a contract basis. We've been counting things that count since 1961. Come see us in Booth 37. Let's talk!

## American Physical Society

**Booth #32A**  
One Physics Ellipse  
College Park, MD 20740  
301-209-3206  
[www.aps.org](http://www.aps.org)

The American Physical Society's Public Outreach Department aims to bring the excitement of physics to all. Stop by to grab our new retro poster series, your copy of Spectra's Quantum leap or hear more about [www.physicscentral.com](http://www.physicscentral.com). We will also be demoing our new comic book app as well as SpectraSnapp for android.

## Arbor Scientific

**Booth #23**  
PO Box 2750  
Ann Arbor, MI 48106  
800-367-6695  
[www.arborsci.com](http://www.arborsci.com)

For 30 years, Arbor Scientific has worked with physics and physical science teachers to develop educational science supplies, science instruments, and physics lab equipment that make learning fun, engaging and relevant for students and teacher's alike. Stop by our Booth and try the most fascinating, dynamic, hands-on methods that demonstrate key concepts and principles of physics and chemistry. We find the cool stuff!

## AU Physics Enterprises

**Booth #32**  
4260 Administration Drive  
HYH-212  
Berrien Springs, MI 49104  
269-471-3503  
[www.physicsenterprises.com](http://www.physicsenterprises.com)

Physics Enterprises designs and manufactures high-quality teaching equipment for science classes. Our products are mainly represented by Vernier Software & Technology, PASCO scientific, VWR, American 3B Scientific, and TEL-Atomic. Visit our Booth to see our latest projects and share your ideas of what your class needs. More information at <https://www.andrews.edu/services/physicsenterprises/>.

## Bedford, Freeman, & Worth High School Publishers

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**Booth #26**  
41 Madison Avenue  
New York, NY 10010  
866-843-3715  
[www.whfreeman.com/physics](http://www.whfreeman.com/physics)

Bedford, Freeman, & Worth (BFW), an imprint of Macmillan Learning, is the most trusted publisher of Advanced Placement® textbooks and resources. Stop by booth 26 to learn more about the highly anticipated 2019 edition of College Physics for the AP® Physics 1 Course, meet author Gay Stewart, enter to win an iOLab from Mats Selen and Tim Stelzer, and more! Get to know us. We know AP® Courses. <https://www.highschool.bfwpub.com/Catalog/>

## Carolina Biological Supply

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**Booth #12**  
2700 York Rd.  
Burlington, NC 27215  
800-334-5551  
[www.carolina.com/distancelearning](http://www.carolina.com/distancelearning)

Give distance learning students a rigorous lab experience with Carolina lab kits designed specifically for college-level distance education. Choose from 200+ hands-on investigations that effectively teach lab skills, data collection and analysis. Or partner with us to customize lab kits to align with your course requirements. [www.carolina.com/distancelearning](http://www.carolina.com/distancelearning).

## Cengage

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**Booth #3**  
303 Second St.  
Ste 500 South  
San Francisco, CA 94107  
415-839-2365  
[www.cengage.com](http://www.cengage.com)

Cengage is an education and technology company, and we've launched a digital subscription program that offers students unlimited access to all our digital products. Visit our booth to learn how WebAssign can help you close the gap in homework and exam scores, and engage students with multisensory learning tools.

## Chesapeake Section, AAPT

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**Booth #22**  
Howard Community College  
Columbia, MD 21044

We are the local AAPT section serving Delaware, Washington D.C., Virginia, and Maryland! Stop by our booth to see some of our favorite simple physics demos and learn how we support local physics instructors. Whether you are local or from another part of the country or the world we would love to trade ideas about promoting physics learning through regional AAPT activities.

## CORD & ETS (Educational Testing Services)

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**Booth #7**  
4901 Bosque Blvd.  
Waco, TX 76710  
254-741-8321  
[www.cord.org](http://www.cord.org)

The Center for Occupational Research and Development (CORD) is a nonprofit organization dedicated to leading change in education. Since 1979, we've been creating educational tools and innovative programs designed to empower faculty and prepare students for greater success in careers and higher education. We invite you to learn more about how CORD assists educators across the country and around the globe.

## Expert TA

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**Booth #25**  
624 South Boston Avenue  
Suite 220  
Tulsa, OK 74119  
877-572-0734  
[www.theexpertta.com](http://www.theexpertta.com)

Expert TA is an online homework and physics learning platform. Emphasizing problem-solving by allowing students to show work has always been central to Expert TA. We have an intuitive interface for students to enter symbolic expressions, a robust math engine that recognizes mathematically equivalent answers, and specific feedback for the most common student mistakes developed through ongoing data-mining efforts. Instructors can assign automatically-graded Free Body Diagram and Vector drawing problems, along with Pre-Class videos and checkpoints. Finally, we recognize that educational exercises are only meaningful if students do the work themselves. We have a comprehensive suite of Academic Integrity tools, and we keep solutions to our problems off the internet.

## Foster Learning LLC

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**Booth #27**  
900 Timberlake Dr.  
Edwardsville, IL 62026  
618-656-6836  
[fosterlearning.education/](http://fosterlearning.education/)

PathPian is a tablet-based digital learning platform designed to teach students how to systematically solve problems. It de-emphasizes the answer and reinforces the process. Test mode provides partial credit for pectoral and mathematical elements. It is also available directly to students as a digital tutor or extra guided practice.

## George Washington University

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**Booth #29a**  
Corcoran Hall  
725 21st Street NW  
Washington, DC 20052  
<https://physics.columbian.gwu.edu/> 202-994-6275

Welcome to DC! The physics department of The George Washington University is glad to serve as host for the 2018 AAPT summer meeting, and to convey a little of our version of the excitement of physics. Stop by for information about our physics graduate programs with special emphasis in astrophysics, biophysics, and nuclear physics, not to mention a side of physics education. The GWU Society of Physics Student chapter will also be represented to showcase some of its exciting activity in science outreach, fun demonstrations, and undergraduate research. Drop by for some physics fun!

## IOP Publishing

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**Booth #28**  
Temple Circus, Temple Way  
Bristol, UK  
44-011 9301153  
[www.ioppublishing.org](http://www.ioppublishing.org)

Physics Education is the international journal for everyone involved with the teaching of physics in schools and colleges. With a worldwide readership and authors from every continent, European Journal of Physics is an international journal dedicated to maintaining and improving the standard of taught physics in higher-education institutes.

## Klinger Educational Products Corp.

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**Booth #16,17**  
86 Glen Cove Road  
Roslyn Heights, NY 11356  
718-461-1822  
[www.KlingerEducational.com](http://www.KlingerEducational.com)

This year KLINGER will be introducing new products that cover a wider range of topics and levels to teach physics. In addition to advanced physics teaching equipment we will also have a selection of items for the high school and middle schools. Come visit and see the capabilities of a ballistics car and lab kits that demonstrate topics such as predicting

trajectories, circular motion, a simple pendulum, accelerated motion and much more. Also being demonstrated will be the LEYBOLD x-ray apparatus and tomography module. Both now have a locking, storage drawer that fits directly under the main units as well as a HD upgrade for the goniometer, enabling a 10X higher resolution achieved through narrower apertures and software. X-rays are detected with an end-window counter or an energy detector. Additionally we will be exhibiting our dependable Electron Diffraction tube and a Ne Franck-Hertz experiment. We look forward to seeing current and new members of the AAPT to say hello and catch up on events happening in the field of physics teaching.

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## Merlan Scientific

**Booth #4**  
**234 Matheson Blvd.**  
**Mississauga, Ontario, Canada**  
**1-800-387-2474**  
**merlanusa.com**

Your source for Quality Optics/Physics teaching equipment. For over 45 years, Merlan Scientific has provided quality Science teaching resources. We are proud to introduce our premium Optics/Physics range. Great institutions such as CUNY endorse our Optics/Physics range, and we think you will be very impressed too. Much of our equipment are made in Europe and 'the accuracy and quality is unrivalled' (CUNY). Join us at Booth 4 to view some of our equipment including our new mecca table, thermal imager, wind tunnel and much more. We will be happy to answer any questions you have and we also have great giveaways and offers including a coupon giving you a huge 15% off your first order with Merlan USA. [www.merlanusa.com](http://www.merlanusa.com); 1800-387-2474; [info@merlanusa.com](mailto:info@merlanusa.com)

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## Morgan and Claypool Publishers

**Booth #13**  
**1210 5th Ave. Suite 250**  
**San Rafael, CA 94901**  
**908-630-7188**  
**www.morganclaypool.com**

IOP Concise Physics (by Morgan & Claypool) publishes short books in over 30 distinct areas of physics. These books provide researchers, teachers, and students with an introduction to key principles in multiple areas, a look back at historical events and people, and also delve into issues surrounding effective teaching methods

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## National Science Foundation

**Booth #10**  
**2415 Eisenhower Ave.**  
**Alexandria, VA 22314**  
**703-292-5111**  
**<https://nsf.gov>**

The National Science Foundation (NSF) has a range of grant programs that support education and workforce development in physics and other STEM disciplines. Stop by NSF's booth for information about funding opportunities and to talk with program staff.

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## National Science Teachers Association

**Booth #17a**  
**61840 Wilson Blvd.**  
**Arlington VA 22201**  
**[www.nsta.org](http://www.nsta.org)**  
**703-312-9210**

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## OpenStax

**Booth #18,19**  
**6100 Main Street, MS-375**  
**Houston, TX 77005**  
**713-348-3674**  
**[www.openstaxcollege.org](http://www.openstaxcollege.org)**

OpenStax is a nonprofit based at Rice University, and our mission is to improve

access to education. Our free, peer-reviewed college textbooks have been used by nearly 700,000 students, and we're piloting adaptive, personalized learning technology that improves student learning. Through philanthropic partnerships, OpenStax is empowering students and instructors to succeed.

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## PASCO scientific

**Booth #1,2**  
**10101 Foothills Blvd.**  
**Roseville, CA 95747**  
**800-772-8700**  
**[www.pasco.com](http://www.pasco.com)**

PASCO designs and manufactures a wide range of physics apparatus including the revolutionary Smart Cart (the Physics Lab on Wheels). Drop by our booth or attend one of our workshops to learn how the Smart Cart, the new Modular Circuits, and PASCO's Essential Physics Curriculum can make your classes easier to teach. One workshop participant will win a free Smart Cart and one will win a Modular Circuits Kit.

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## Pearl Insurance

**Booth #33**  
**1200 E. Glen Avenue**  
**Peoria Heights, IL 61616**  
**309-697-0385**  
**[www.apsitinsurance.com](http://www.apsitinsurance.com)**

Need Help Investigating Insurance? We've Done the Research for You. The American Physical Society Insurance Trust (APSIT) takes the guesswork out of the equation. Access affordable coverage including life and disability for scientific professionals. APSIT offers trusted protection for you and your loved ones. Visit Booth #33 to learn more.

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## PlaneWave Instruments

**Booth #22A**  
**1819 Kona Dr.**  
**Rancho Dominguez, CA 90220**  
**[www.planewave.com](http://www.planewave.com)**  
**310-639-16623**

PlaneWave Instruments, Inc. supports astronomy education and STEM by producing a full line of telescopes, mounts and related products which meet high standards for quality student work as well as the rigors of professional research.

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## Quantum Experience Ltd.

**Booth #5**  
**Moskovich 13/34**  
**Rehovot, Israel 7617413**  
**972773179301**  
**[www.quantumlevitation](http://www.quantumlevitation)**

Stimulate and encourage students to learn PHYSICS by teaching them the amazing phenomenon of Quantum Levitation. Quantum Experience develops educational programs using superconductors and quantum levitation. Our experimental kits and supporting material allow students to study Quantum Levitation, experience in a research process of learning and develop important scientific learning skills.

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## Society of Physics Students

**Booth #35**  
**One Physics Ellipse**  
**College Park, MD 20740**  
**301-209-3008**  
**[www.spsnational.org](http://www.spsnational.org)**

The Society of Physics Students (SPS), along with Sigma Pi Sigma, the national physics honor society, are chapter-based organizations housed within the American Institute of Physics. SPS strives to serve all undergraduate physics students and their mentors with a chapter in nearly every physics program in the country and several international chapters. Sigma Pi Sigma, with over 95,000 historical members, recognizes high achievement among outstanding students and physics professionals. SPS and Sigma Pi Sigma programs demon-

strate a long-term commitment to service both within the physics community and throughout society as a whole through outreach and public engagement. Partnerships with AIP member societies introduce SPS student members to the professional culture of physics and convey the importance of participation in a professional society. SPS and Sigma Pi Sigma support scholarships, internships, research awards, physics project awards, outreach/service awards, and a job site for summer and permanent bachelor's level physics opportunities (jobs.spsnational.org).

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## SPS Local Chapters

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**Booth #34**  
**Society of Physics Students & Sigma Pi Sigma**  
**One Physics Ellipse**  
**College Park, MD 20740**  
**www.aip.org**

Come interact with the local chapters of the Society of Physics Students! Undergraduate physics and astronomy students of regional SPS chapter will be available to show off their activities, outreach, demos, and chapters. Stop by to learn or just connect.

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## Spectrum Techniques

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**Booth #11**  
**106 Union Valley Road**  
**Oak Ridge, TN 37830**  
**865-482-9937**  
**www.spectrumtechniques.com**

Spectrum Techniques, the leading supplier of nuclear GM counting equipment, Exempt Quantity radioisotopes, and nuclear spectrometers is now showcasing a wifi enabled radiation counter with standard ethernet and USB.

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## The Education Group

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**Booth #29**  
**415 N. Orange Grove Ave.**  
**Los Angeles, CA 90036**  
**physicdemos.com**

The Video Encyclopedia of Physics Demonstrations. Teaching physics is made easier with this comprehensive curated series of 600 videotaped demonstrations and 4000 pages of related written material in English in Spanish and Portuguese. Designed for use by University, K 7-12 students, these videos clearly presented with optional subtitles allow professors to present and students to view a wide range of physics demonstrations not otherwise available to them but important for their understanding of physics concepts.

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## Thomas Jefferson High School for Science & Technology

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**Booth #2A**  
**6560 Braddock Road**  
**Alexandria, VA 22312**  
**703-750-8300**  
**www.tjhsst.fcps.edu**

Thomas Jefferson High School for Science and Technology is recruiting physics teachers for the 2019–2020 school year and beyond. As a global leader in STEM education, TJHSST empowers students and staff to explore, create, and invent. Our forward-thinking school goes beyond traditional boundaries and expectations to achieve amazing things.

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## Utah Valley CVB

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**Booth #9**

Utah Valley is a beautiful place for any conference, meeting or retreat. Enjoy the natural beauty and diversity of the Wasatch Front. Hang gliding, world class fly-fishing, skiing, and dinosaur hunting are just a few of the many outdoor adventures in Utah Valley. Utah Valley incorporates a modern element of resorts and lodging, museums, performing arts, festivals and much more.

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## Vernier Software and Technology

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**Booth #14,15**  
**13979 SW Millikan Way**  
**Beaverton, OR 97005**  
**888-837-6437**  
**www.vernier.com**

Vernier Software & Technology is the leading worldwide innovator of real-time data-collection, graphing, and analysis tools for science education. Visit our booth to explore easy data collection and analysis with sensors and Graphical Analysis 4 software.

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## Wards Science

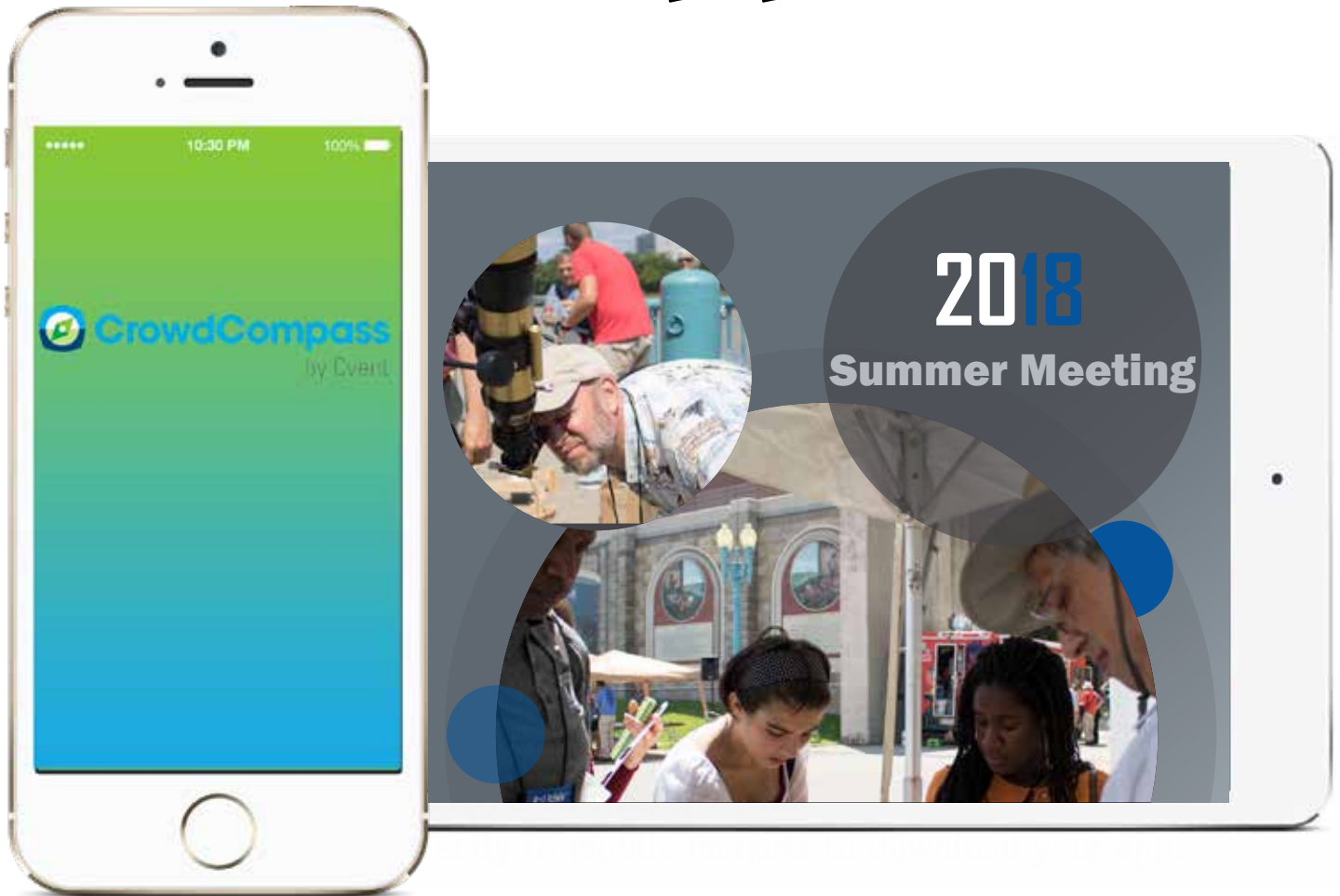
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**Booth #24**  
**P. O. Box 92912**  
**Rochester, NY 14692**  
**800-962-2660**  
**www.wardsci.com**

All you need to turn science lessons into science connections. Ward's Science is the exclusive distributor for all Cenco Physics products, connecting you to the same world-class quality and innovative physics apparatus and experiments you know from Cenco, plus a wide selection of additional physics related activities, kits, and supplies.



# Download Your Mobile App Now!



## To Download the App

- Go to your Apple "App Store" or Android "Play Store" and download the "CrowdCompass AttendeeHub" app
- Under "Search for Event" type in "AAPT" and click on the "2018 AAPT Summer Meeting" The event password is "**sm2018**"

**NEW!**

Stop by our Mobile App Help Desk near Registration for help in using the app:

—Monday, July 30: 10 a.m.–2 p.m.

—Tuesday, July 31: 10 a.m.–2 p.m.



T W E E T U P

**#AAPTSM18**

MEET YOUR PHYSICS TWEETS IRL  
OR LEARN HOW TO USE SOCIAL  
MEDIA TO BENEFIT YOUR  
TEACHING.

SUN 07/29, 5:00PM - 6:00PM  
CARNEGIE ROOM

Join the nation's  
largest meeting dedicated to the  
education of future physics teachers

# 2019 PhysTEC Conference

March 2-3  
The Westin Boston Waterfront  
Boston, MA

[phystec.org](http://phystec.org)

## SAVE THE DATE

- Special Workshop:  
'Get the Facts Out' toolkit  
for recruiting teachers
- Study Results: Building  
Thriving Physics Teacher  
Education Programs
- Networking with leaders in  
physics teacher education

And more!



**NEW!**



## Lactation Room

(Meeting Planners  
Office C)

Hours:

Saturday – 7 a.m. to 10 p.m.

Sunday – 7 a.m. to 10 p.m.

Monday – 7 a.m. to 10 p.m.

Tuesday – 7 a.m. to 10 p.m.

Wednesday – 8 a.m. to 10 p.m.



## Early Career & First Timers' Social

Tuesday, July 31  
12:00-1:30 PM

@City Tap House  
Penn Quarter

Take this opportunity to meet and mingle with other "Newbies" and Early Career Professionals!

Appetizers Provided  
Cash Bar

# LabEscape

*The future of the free world  
is in your hands... are you up to  
the challenge of the world's first  
science-based escape room?*

*"This was a fantastic  
experience!!! A must  
visit!" – Colin L.*



*"Hands down the best  
escape room I've ever  
done!" – Colleen D.*

**Escape:** [verb] *ə'skɑ:p* to break free from confinement or control.

**Escape Room:** [noun] *ə'skɑ:p rʊm* a recreational and team-building activity in which a group of people are locked into a room, often with some goal, and attempt to escape by solving a sequence of fun and challenging puzzles.

**LabEscape:** [noun] *lab ə'skɑ:p* the world's only science-based escape room (an outreach project of the Dept. of Physics of the University of Illinois), in which 4-6 intrepid Agents must solve the mystery of Professor S., save the free world, and escape her secret lab. Running NOW at the AAPT meeting!

**[Plan YOUR escape today at LabEscape.org/AAPT](http://LabEscape.org/AAPT)**

**ILLINOIS**

**I**

**PHYSICS**

Monday, July 30, 2018 – Session Schedule

(NOTE: Session rooms at Marriott Marquis in orange)

Poster Session 1, 8:30–10 p.m., Grand Ballroom South

	China-town	Mt. Vernon Square A	Mt. Vernon Square B	Magnolia	Cherry Blossom	Dogwood	Meeting 8/9	Silver Linden	Scarlet Oak	Cong. Ballroom A	Tulip	Meeting 10/11	Meeting 5	Cong. Ballroom B	Meeting 4	Meeting 2	Meeting 3	Renais- sance	
8:30 a.m.	AA: PER: Instructor Support, Professional Dev., Program and Institutional Change	AB: PER: Mathematical Reasoning and Problem Solving	AC: Effective Practices in Educational Technology	AD: High School	AE: Inclusivity and Diversity in STEM	AF: Introductory Labs/Apparatus	AG: Introductory Physics for Life Science: Pedagogy and Practice	AI: Learning More about Getting Involved in AAPT Committee Work: A Primer	AJ: Physics and Product Innovation	AK: PTBA, Make, Play, Do	AL: Stories and Science Teaching	AM: Long-Term, Distributed Faculty ...	AN: Astronomy	AO: Gender	AP: Interactive Lecture Demos:	TOP01: Early Career Topical Discussion	TOP02: Explore Your Concept Inventory Data with the PhysPort Data Explorer		
9:00																			
9:30																			
10:00																			
10:30																			
11:00																			
11:30																			
12:00																			
12:30 p.m.																			
1:00																			
1:30	BB: Using Historical and Popular Texts in Physics Teaching	BH: Assessment, Grading and Feedback	BI: Student Content Understanding, Problem-Solving and Reasoning	BC: Exchange of Ideas and Faculty in Teacher Preparation	BL: Technology for Accessibility and Inclusion	BE: High School Teachers Doing Action Research	BG: Introductory Courses	BH: Innovations in Teaching Astronomy	BD: Get Started! Integrating Computation Into Courses at Any Level	BA: Interdisciplinary Studies and Support, and Curriculum and Instruction	BM(A): Scientific Activism	BM(B): Science, Society and Outreach		BK: Remembering Millie Dresselhaus		BJ: PTRA Developing Women in Physics in K-12			
2:00																			
2:30																			
3:00																			
3:30																			
4:00																			
4:30																			
5:00																			
5:30	CK: The Art and Science of Teaching	CA: Laboratories and Experiments	CB: Reasoning, Sensemaking and Modeling	CC: Contributing to, and Using, the IJLS Portal	CD: Exchange of Ideas and Faculty in International Teacher Preparation:	CM: 30 Demos in 60 Minutes	CG: Lessons Learned in the Robert Noyce Scholarship Program	CF: K-12 PER	CE: Exploring Experiments with Augmented Reality	CH: NSF ADVANCE Program	CI: The Latest & Greatest Electronic Resources from the AAPT and How to Access Them on the Web	CJ: Peer Review and the Peer Review Process	CJ: Model Gravitation Waves in YOUR Classroom						
6:00																			
6:30																			
7:00																			
7:30																			
8:00																			
8:30																			

Awards Session Teaching Awards

Plenary: Shirley Malcom

(NOTE: Session rooms at Marriott Marquis in orange)

## Tuesday, July 31 – Session Schedule

	Chinatown	Mt. Vernon Square A	Mt. Vernon Square B	Magnolia	Cherry Blossom	Dogwood	Meeting 8/9	Silver Linden	Scarlet Oak	Cong. Ballroom A	Tulip	Meeting 10/11	Meeting 4	Cong. Ballroom B	Meeting 3	Meeting 2	Renaissance
8:30 a.m.																	
9:00	DE: History of Historically Black Colleges and Universities	DA: PER: Curriculum and Instruction and Student Content Understanding	DC: Best Practices in Educational Technology	DF: Introductory Labs/Apparatus II	DI: Star Trek Physics	DH: "Demos Changed My Life!"	DB: PER: Self-Efficacy, Motivation, Mindset and Epistemology	DG: Physics Identity in Informal Programs	DK: Tracking, Mentoring, and Induction of New Teachers	DD: Exploring Physics Apps and Learning to Use Them	DJ: The Model Minority Myth and Disaggregation of Asian Student Data	DL: Upper Division Undergraduate	DM: Writing in the Physics Curriculum: Objectives, Implementation, and Assessment				
9:30																	
10:00																	
10:30																	
11:00																	
11:30																	
12:00 p.m.																	
12:30																	
1:00																	
1:30																	
2:00	EM(A): 2 Year Colleges and 4 Year Institutions	EB: Cutting-Edge Educational Technology From Europe	EH: PER: Diversity, Equity & Inclusion	EB: Cutting-Edge Educational Technology From Europe	EC: Experimental Design at All Levels	ED: Frontiers of Astronomy	EE: Learning Assistants' Role in Attracting Community in Physics Departments And Beyond	EE: Improving Accessibility for Physics Students with Visual or Cognitive Disabilities	EL: Assessment in Physics teacher Preparation	EA: PER: Cognition, Meta-cognition, Reasoning	EF: Introductory Courses II	EK: Upper Division and Graduate Courses and Labs	EG: Learning Assistants: Role in Affecting Community in Physics Departments and Beyond	EG: Learning Assistants: Role in Affecting Community in Physics Departments and Beyond	EJ: PTRA: Literature in K-6 Science	EI: Professional Skills for Graduate Students	
2:30	TOP03: Challenges in Physics at the TYC																
3:00																	
3:30																	
4:00																	
4:30																	
5:00																	
5:30	FC: Best Practice in Teacher Professional Development	FA: PER: Assessment, Survey Methods and Machine Learning	FL: Research Traditions within PER: Perspectives of the field from Experienced Researchers	FF: Experiences in Washington: Internships and Fellowships	FG: Integrating History of Science into Physics Courses	FH: Professional Development: Effects on Physics Teachers	FI: Promoting Student Clubs and Cohorts	FJ: PTRA: Hollywood Physics	FK: Reducing the Gender Gap in Undergraduate Physics	FM: Writing in the Physics Curriculum: Objectives, Implementation, II	FN: Reducing the Gender Gap in Undergraduate Physics						
6:00																	
6:30																	
7:00																	
8:30																	
9:30																	

Poster Session 2, 9:30–11 a.m., Grand Ballroom South

(NOTE: Session rooms at Marriott Marquis in orange)

Wednesday, Aug. 1 – Session Schedule

Poster Session 3, 3–4:30 p.m., Grand Ballroom Foyer

	Magnolia	Cherry Blossom	Dogwood	Meeting 5	Silver Linden	Scarlet Oak	Meeting 8/9	Cong. Ball A	Meeting 13/14	Meeting 4	Meeting 15	Meeting 3	Meeting 2	Renais- sance
8:30 a.m.														Awards: Klopsteg Memorial Lecture Award
9:00														
9:30														
10:00														
10:30														
11:00														
11:30														APS Plenary: The Proton Radius Puzzle and The Coming Quantum Revolution
12:00 p. m.														
12:30														
1:00														
1:30	GN: Teacher Training/ Enhancement	GD: Council on Undergraduate Research	GF: Integrating His- tory of Science into Physics II	GM: STEP UP 4 Women	GH: Models-based Physics Education - A Wendell Potter Memorial	GG: Models for Integrating Computation into Undergrad- uate Physics	GB: PER: Group- work, Interac- tions, Culture and Nature of Science	GI: Physics Beyond the Core	GA: PER: Informal Settings, Accessibility, and Inclusion	GL: Physics Majors: Middle School to Doctorate	TOP05: Graduate Student Topical Discussion	GK: Physics Laboratories in the NSF IUSE Program	GJ: Physics for Refugees & Distant Education	
2:00														
2:30														
3:00														
3:30							HD: Post- deadline Abstracts IV		HC: Post- deadline Abstracts III	HB: Post- deadline Abstracts II			HA: Post- deadline Abstracts I	PERC: Bridging Session
4:00														
4:30														



## Session SPS: SPS Undergraduate Research and Outreach Posters

Location: Grand Ballroom North/Central Sponsor: AAPT/SPS Time: 7:00–9:00 p.m. Date: Sunday, July 29 President: Brad Conrad

### SPS01: 7:00–9:00 p.m. Meeting the Science and Mathematics Education Needs of Grandparent-Headed Families

Poster – Bonggu Shim, Binghamton University, PO Box 6000, Binghamton, NY 13902-6000; bshim@binghamton.edu

Elizabeth Anderson, Youjung Lee, Binghamton University

There are 2.7 million grandparents raising their grandchildren in the U.S. These marginalized families express increasing concerns about supporting their grandchildren in science and mathematics education. An interdisciplinary program focusing on science and mathematics education for grandparent-headed families was developed using a school-university partnership model. This program was implemented in a small city in the Northeast over a two-year period. Lessons learned from the custodial grandparents and university students and faculty participating in this interdisciplinary program include: (a) grandparents' increased self-efficacy in assisting with their grandchildren in science and math education; (b) university students' increased connection to families' intergenerational learning at home; and, (c) interdisciplinary school-university partnerships as an innovative way to meet unique needs of grandparent-headed families and achieve universities' goals toward civic engagement and applied research.

### SPS02: 7:00–9:00 p.m. Physical Models of the Toroidal Dipole

Poster – Angel Gutarra-leon, Northern Virginia Community College, 10594 Reeds Landing Cir., Burke, VA 22015; agutarr2@masonlive.gmu.edu

Walerian Majewski, Northern Virginia Community College

We have investigated two models of the third elementary electromagnetic dipole, known as the toroidal dipole. Its magnetic realization is a circumferentially magnetized ring constructed of neodymium. The electric model of the dipole is a toroidal coil connected to a DC voltage. The electric and magnetic toroids produce only an inner magnetic field, inside the torus, and interact only on contact with the electric current density or with a time-dependent electric field. We studied the characteristics of a permanent-magnet toroid and observed the influence of electric and magnetic fields on it. A static toroidal dipole moment of this magnetic toroid was measured in interaction with the external current. The role of toroidal dipoles in particle physics and in technology is discussed.

### SPS03: 7:00–9:00 p.m. OSA and SPS Summer Internship Program

Poster – Michael R. Forkner, 2944 23rd Ave. NW, Albany, OR 97321-6511; mike.forkner@gmail.com

This summer I worked at The Optical Society (OSA) helping to redesign, update, and relaunch their Optics for Kids website. My main summer goal was to review all the material on the site to ensure that the content was up to date the physics was correct. I had a stretch goal of creating new web pages focusing on resources to help elementary, middle, and high school teachers teach optics. While I only made small progress towards my stretch goal, throughout the summer I picked up other smaller projects that I not only enjoyed but also greatly helped my own professional development. These projects included blogging on different incubators, which are small conference style meetings of focused and niche physics topics, and blogging on the OSA Innovation school, a four-day school where students learn to harness their entrepreneurship and innovation to create new products for their business.

### SPS04: 7:00–9:00 p.m. Random Phase Approximation Susceptibility

Poster – Zhenxiong Xie, School of physics, Sun Yat-Sen University, No. 135 Xingangxi Road, Guangzhou, Guangdong 510275 P. R. China zhenxiong.xie@yahoo.com

usceptibility is a linear response function that describes the properties of high temperature superconductors. Moreover, susceptibility of interacting Fermions is introduced to calculate the approximate analytic solution of superconducting gap through random phase approximation (RPA). This work shows Matsubara Green function and the RPA susceptibility. In addition, multi-orbital Hubbard Model is also introduced.

### SPS05: 7:00–9:00 p.m. Scientific Literacy and Links to Attitudes Towards Science Policy

Poster – Danielle Roslyn Montecalvo, The American University, 4400 Massachusetts Ave. NW, Washington, DC 20016-2328; dm9152a@student.american.edu

One hundred twenty randomly selected undergraduate participants at American University were surveyed during the fall 2017 semester to assess the potential relationships between scientific literacy and attitudes toward space exploration. Motivated by a 2009 study conducted by Cook, et. al. [1] at Syracuse University, the present study explores the topic: How does the scientific literacy of undergraduate college participants affect their attitudes toward space exploration? Consistent with the Cook study, results from the current study reveal that there was a positive correlation between scientific literacy scores and attitudes toward space exploration ( $\rho = 0.224$ ,  $P < 0.05$ ). These results suggest that a higher scientific literacy tends to support slightly more favorable attitudes toward space exploration within the population of undergraduates surveyed.

[1] S. B. Cook, M. Druger, and L. L. Ploutz-Snyder, "Scientific literacy and attitudes towards American space exploration among college undergraduates," *Space Policy*, vol. 27, no. 1, pp. 48–52, 2011. Sponsor: Teresa Larkin, AAPT Member

### SPS07: 7:00–9:00 p.m. Students' Understanding of "Instantaneous" Acceleration

Poster – Michael Danis,\* The University of North Carolina at Chapel Hill, CB 3255, Chapel Hill, NC 27599-3255; mdanis@live.unc.edu

Duane L. Deardorff, The University of North Carolina at Chapel Hill

Answers to a commonly missed question on introductory physics exams for students at the University of North Carolina at Chapel Hill were critically analyzed to pinpoint sources of conceptual misunderstanding. The question asks students to compare the forces acting on a ball of clay as it lands on the floor. Many students say that the force of the floor is less than or equal to the weight of the clay ball because it does not rebound. The responses to this question were analyzed and curriculum changes were proposed in order to address the student misconception.

\*Sponsored by Duane Deardorff

### SPS08: 7:00–9:00 p.m. Understanding Comprehension of Forces and Spatial Reasoning in Introductory Mechanics

Poster – Danny Rivas, California State University, Dominguez Hills, 347 1/2 west 70th St. Los Angeles, CA 90003-1832; dannyr110@gmail.com

Ximena Cid, California State University, Dominguez Hills

Our group is interested in understanding the relationship between visual/spatial cognition and comprehension in physics content. In particular we wanted to understand if there are differences between gains in comprehension, as measured by the Force Concept Inventory, between lecture instructors and to explore the

relationship between spatial reasoning skills, as measured by the Mental Rotation Test, and one's ability to excel in physics. Data was collected at the beginning of the semester and end in order to assess the level of content preparation students come into introductory physics with and to quantify how much students learn during the semester. Using statistical tests such as the analysis of variance, (ANOVA), we compared the difference of means for two variables: instructor and content. This poster will focus on the data analysis of the ANOVA, as well give a discussion to describe any relationships we find between spatial reasoning and student comprehension.

#### **SPS09: 7:00-9:00 p.m. Comparison of Calculus-based and Algebra-based SCALE-UP Physics**

Poster – Abigail Hurley,\* Miami University, 500 E Spring St., Oxford, OH 45056; hurleyaf@miamioh.edu

Jennifer Blue, Miami University

At Miami University, we use SCALE-UP methods to teach both our algebra-based and calculus-based introductory physics courses. In principle, these courses cover the same subjects in the same manners. The students are not the same: the calculus-based course is taken by engineering majors, mostly men in their first year of college, and the algebra-based course is taken by health science majors in their junior year, with a balanced gender distribution. Now that we have been teaching these courses in this manner for a few years, we have noticed some differences in the way the students interact with the instructors and the material. Observations of the summer courses, plus student surveys and scores, will help us to confirm or correct our assumptions.

\*Sponsored by Jennifer Blue

#### **SPS10: 7:00-9:00 p.m. Effect of an iPad-based Physics Curriculum on Pre-service Elementary Teachers' Technology Self-efficacy**

Poster – Matthew J. Conway, Towson University, 8000 York Road, Towson, MD 21252; mconwa9@students.towson.edu

Deepika Menon, Towson University

This study investigates a set of variables influencing pre-service elementary teachers' technology self-efficacy as they engage in an innovative iPad-based physics curriculum, Exploring Physics. Specifically, we investigated, (1) the impact of computer-based courses taken at the high school or college level and, (2) the prior possession of an iPad, on participants' technology self-efficacy. Participants included 92 pre-service elementary school teachers enrolled in a semester-long physics content course. Data were collected using a Technology Self-efficacy survey and an open-ended questionnaire. Data analysis included linear regression to understand the effect of variables on participants' technology self-efficacy. Results showed that computer-based courses were a significant contributor, while the possession of an iPad had little influence on technology self-efficacy. This result implies that using technology in a general sense may not necessarily affect pre-service teachers' confidence to use technology, while meaningful hands-on experiences can foster their willingness to integrate newer technologies in physics teaching.

#### **SPS11: 7:00-9:00 p.m. Fast Multipole Method for N-Body Simulations Applied to Physical Systems**

Poster – Aaron T. Hutchins, Syracuse University, 6 Spindlewick Drive, Nashua, NH 03062-4512; athutchi@syr.edu

Christopher F. Kane, Meghan K. Lentz, Patrick Miles, Walter Freeman, Syracuse University

With modern consumer grade computers, it is possible to simulate the physics of N body systems by computing all pairwise interactions on each particle exactly. Computational cost of this method scales as  $O(N^2)$ , however, which makes simulating large N systems impractical on the typical computer. In order to simulate interesting physics with large N, approximations must be made to decrease the number of force calculations required per timestep. In our work, we implemented the fast multipole method, which can decrease computational cost to  $O(N \log N)$  or  $O(N)$ , vastly speeding up calculations. We present our study of the complicated relationship between computational gain and loss of accuracy in the force calculations with the implementation of this method. In addition, we have applied this algorithm to the study of planetary ring dynamics, solar system formation and fluid dynamics.

#### **SPS12: 7:00-9:00 p.m. Higgs Field's Vacuum Expectation Value from the Muon Decay**

Poster – Angel Gutarra-leon, Northern Virginia Community College, 10594 Reeds Landing Cir., Burke, VA 22015; agutarr2@masonlive.gmu.edu

Walerian Majewski, Northern Virginia Community College

Cosmic ray (atmospheric) muon decays into an electron and two neutrinos. By detecting the delay time between arrival of the muon and an appearance of the decay electron in our scintillation detector, we measured the muon's average lifetime at rest in the material of our detector. From the lifetime, using the Standard Model of Fundamental Particles' relations and an experimental value for masses of W boson  $M_W$  and of the muon  $m_\mu$ , we calculated the vacuum expectation value of the Higgs field to be  $v = 207 \text{ GeV}/\sqrt{2}$ , as well as the universal weak and electric charges. We measured the sea-level fluxes of both low-energy (below 140 MeV) and high-energy muons. We also found the shapes of the energy spectra of low-energy muons and of their decay electrons. We attempted to measure the stopping power of muons in lead shielding.

#### **SPS13: 7:00-9:00 p.m. Novel Nanostructures Syntheses Toward Third Generation Solar Cell**

Poster Andrew Nunez, St. John's University, 8000 Utopia Pkwy., Jamaica, NY 11439 longg@stjohns.edu

Sedariest Hammond, Dominic Tran, Mostafa Sadoqi, Gen Long, St John's University

Third-generation solar cell devices aim to increase power conversion efficiency from sunlight and decrease cost of materials production compared to first-generation silicon based solar cells, despite the theoretical limit set by Shockley and Queisser. In this poster we present an experimental study on an approach of Zinc Oxide nanowires, PbS nanoparticles, and ITO plate substrates to form heterojunction colloidal quantum dot solar cells via chemical synthesis. The process includes nanowire annealing and growth, nanoparticle synthesis and ligand exchange, and spin coating fabrication of the solar cell. In addition, we introduced gold nanoparticles to the cells and have shown that these increase light absorption via plasmonic effect, with results characterized by XRD, TEM, SEM and UV-Vis-NIR spectroscopy.

#### **SPS14: 7:00-9:00 p.m. Inductional Magnetic Levitation**

Poster – Angel Gutarra-leon Northern Virginia Community College 10594 Reeds Landing Cir. Burke, VA 22015 agutarr2@masonlive.gmu.edu

Walerian Majewski, Northern Virginia Community College

Vincent Cordrey, College of William and Mary

Brady Murphy, Virginia Polytechnic Institute

Sephehr Samiei, University of Virginia

We constructed three circular neodymium magnet array wheels in both Halbach and non-Halbach configurations with strong alternating-polarity magnetic fields on the outer rims of the wheels. Such systems are referred to as electrodynamic wheels (EDW). A Halbach array is a series of magnets which have their magnetic dipole directions rotated by 90 degrees at each adjacent position. Our non-Halbach array created somewhat weaker

alternating fields around the rim with magnetic dipole moments arranged circumferentially with reversing polarity. Our experiments measured the lift and drag forces produced by these spinning wheels on conducting plates which play a role of the tracks, at varying rotation speeds of the wheels. These forces were compared with theoretical predictions for the ratio of lift to drag. We found that the lift to drag ratios for both measured wheels followed the predicted linear relationship as functions of angular velocity of the rotating magnetic field. We expand here on our construction of a Halbach EDW with tightly-spaced magnets. (Supported by NVCC Educational Foundation, Virginia Academy of Science and the Society of Physics Students). Sponsored by Jorge Del Carpio.

**SPS15: 7:00-9:00 p.m. Roger That! Say YES to a Successful Collaboration**

Poster – Karen Gipson, Grand Valley State University 1 Campus Drive, 224 Lake Ontario Hall Allendale, MI 49401-9403 gipsonk@gvsu.edu

Deana Weibel, Samhita Rhodes, Glen Swanson, Grand Valley State University

Emily Hromi, Grand Rapids Public Museum

Roger That! is a two-day public symposium on space exploration named in honor of Roger Chaffee, a native Grand Rapidian who lost his life in the Apollo 1 fire. The symposium is organized by faculty at Grand Valley State University (GVSU) in collaboration with staff at Grand Rapids Public Museum (GRPM). Keynote speakers are featured, along with presentations by local experts aimed at college students and the general public on scientific and societal considerations of space exploration. The first day also includes a Design Challenge for 5th-8th graders, K5 field trips, and planetarium shows. The second day features family-friendly activities at GRPM. Funded in part by the Michigan Space Grant Consortium.

## K-12 Teachers' Lounge

### Lafayette Room

Come visit to engage in hands-on laboratory activities and learn about AAPT Digi Kits.

The lounge is open Monday–Wednesday with the following schedule of activities:



**Monday, July 30, (K-12 Teachers' Day )**

- 8-9 a.m. Sunspots Period & Frequency
  - 9-10:30 a.m. Acoustics Collection
  - 12-1 p.m. Analog to Digital
  - 1-2 p.m. Medical Imaging
  - 2-3 p.m. DNA Crystallography
  - 3-3:30 p.m. Photoelectric Effect
  - 5-6:30 p.m. STEP UP 4 Women Working Reception
- Join this reception to learn about how to STEP UP 4 Women in physics by using research-based lessons to increase women's physics identity.*  
**(Come to Meeting Room 10/11)**

**Tuesday, July 31**

- 8-9 a.m. Open Lounge
- 9-10 a.m. Measuring Coronal Mass Ejections
- 12-1 p.m. Terminal Velocity in Fluids
- 1-2 p.m. Popper Energy
- 2-3 p.m. Geoelectric Fields
- 3-3:30 p.m. Nerve Science
- 5-6 p.m. Computational Modeling in Physics  
*Get teaching materials and engage in discussion with the project leadership.*

**Wednesday, August 1**

- 9-10 a.m. Social Justice in Physics  
*Join a conversation about teaching social justice in physics with high school teacher Moses Rifkin.*
- 10 a.m.-4 p.m. Open Lounge
- 10-11 a.m. Get the Facts Out  
*Join this session to get new materials to help change the conversation around how people perceive K-12 teaching.*

### CW01: Expert TA: Learning Resources beyond Online Homework

**Location:** Meeting Room 16    **Date:** Monday, July 30    **Time:** 12:00-1:00 p.m.

*Sponsor: Expert TA*

*Leader: Dr. Jeremy Morton*

There are a broad range of learning resources available now, but because these are spread out across many different platforms, utilizing them can be difficult for instructors and add additional cost to students. Expert TA continues to enhance our online homework system, but we have also begun to develop additional educational tools in order to provide these from one centralized location. Beginning in Fall 2018 instructors will be able to assign Pre-Class videos for both Algebra and Calculus-based sequences, use Clicker-Style questions, utilize an advanced Academic Integrity tool suite that effectively keeps students off of answer-sharing websites, and more. In addition, building off the success of our automatically graded Free Body Diagrams released in Fall 2017, we are developing Extended FBDs and Vector Drawing problems. During the workshop we will offer a preview of these resources. We will also discuss the differentiating features of Expert Ta's online homework system. Our textbook independent library helps to reinforce the problem-solving process with an abundance of multi-step questions. The majority of these problems involve symbolic answers, and based on a six-year data-mining initiative students receive specific and meaningful feedback for incorrect answers. Please join us for lunch if you are interested in learning more.

### CW02: PASCO: Simplify Basic Circuit Instruction with Modular Circuits

**Location:** Meeting Room 15    **Date:** Monday, July 30    **Time:** 12:00-1:00 p.m.

*Sponsor: PASCO scientific*

*Leader: Brett Sackett*

Join PASCO for a hands-on workshop on basic circuits topics with Modular Circuits! Our Modular Circuits simplifies the instruction of basic circuits by giving students a tactile means to go from the schematic diagram to a working circuit. From lighting a single light bulb to Kirchhoff's circuit laws, Modular Circuits does away with the confusion of tangled wires and lets students focus on the physics concepts around basic circuits.

### CW03: Linear Momentum & Collisions with the PASCO Smart Cart

**Location:** Meeting Room 15    **Date:** Monday, July 30    **Time:** 1:30-2:30 p.m.

*Sponsor: PASCO scientific*

*Leader: Brett Sackett*

Join PASCO for a hands-on workshop on Linear Momentum and Collisions with the Smart Cart! The Smart Cart wirelessly measures force, position, velocity and acceleration – everything you need to understand Impulse, linear momentum conservation, and collisions. We will collide Smart Carts and explore this very fun area of physics instruction.

### CW04: Essential Physics – A PASCO Physics Curriculum with Simulations, Videos, and Interactive Equations

**Location:** Meeting Room 15    **Date:** Monday, July 30    **Time:** 3:00-4:00 p.m.

*Sponsor: PASCO scientific*

*Leader: Dr. Tom Hsu*

Come take a tour of *Essential Physics* 3rd Ed. with Dr. Tom Hsu. *Essential Physics* is an algebra-level physics curriculum from PASCO that is both a physical textbook as well as a feature rich eBook. See the many resources contained in *Essential Physics* including: teacher Power Point slides, lesson plans, interactive equations, simulations, videos, quizzes, and an infinite test generator.

### CW05: Introducing Pivot Interactives from Vernier

**Location:** Meeting Room 15    **Date:** Tuesday, July 31    **Time:** 12:00–1:00 p.m.

*Sponsor: Vernier Software & Technology*

*Leader: Josh Ence*

*David Vernier, John Gastineau*

Pivot Interactives is a customizable online-video environment that is a superb complement to hands-on experiments with Vernier sensors. Students are quickly engaged by these high-production-quality videos of hard-to-implement phenomena, which are a powerful supplement to hands-on experimentation. Explore the possibilities with us!

### CW06: Vernier Solutions for Physics and Chromebooks

**Location:** Meeting Room 15    **Date:** Tuesday, July 31    **Time:** 1:00–2:00 p.m.

*Sponsor: Vernier Software & Technology*

*Leaders: Josh Ence*

*David Vernier, John Gastineau*

Bring your Chromebook (or use one of ours) and learn how easy it is to connect sensors and collect and analyze data. Explore the free Graphical Analysis 4 app for data collection.

## CW07: College Physics: Explore and Apply 2nd Edition: Help Students Learn Physics by Doing Physics

Location: Meeting Room 16

Date: Tuesday, July 31

Time: 12:00-1:00 p.m.

Sponsor: Pearson

Leader: Eugenia Etkina

The lead author of *College Physics: Explore and Apply*, Eugenia Etkina, will discuss how she employs an active learning approach with her students and how the changes in the second edition of *College Physics* address the needs of the changing world. She will show how the written text, Active Learning Guide, and Mastering Physics can engage students in practicing science while learning physics. A myriad of new experiments and innovative problems will motivate your students to learn physics and help them succeed on revised assessments – such as AP exams and MCAT. Come and learn about the exciting developments in the whole learning system and receive a signed book by the authors!

### Workshops – at George Washington University (see bus schedule, page 37)

KEY: COR: Corcoran Hall SEH: Science and Engineering Hall

#### T01: PTR: Cartoon Physics

Sponsor: Committee on Physics in Pre-High School Education

Time: 8:00-10:00 a.m. Saturday

Member Price: \$65 Non-Member Price: \$90

Location: Meeting Room 2 (at Renaissance)

Kenric Davies, 1508 Castle Creek Dr., Little Elm, TX 75068; kenric.davies@gmail.com

Looking for more engaging science examples for your elementary or middle school classroom? In this session, we will break down scenes from classic cartoons like Coyote and Roadrunner, Speedy Gonzales, and other cartoon movies using physics concepts taught in the elementary and middle grades. Teachers will go through a few hands on experiments that their students can do to test whether or not the cartoon scenes showed good or bad physics. Teachers will also use the CER (Claim, Evidence, and Reasoning) method of developing good scientific explanations that are grade level appropriate. Participants will receive information on where to find each clip and hands on materials for easy use in the classroom.

#### W01: Developing and Implementing NGSS Three-Dimensional High School Physics Lessons

Sponsor: Committee on Physics in High Schools

Co-sponsor: Committee on Teacher Preparation

Time: 8:00 a.m.-12:00 p.m. Saturday

Member Price: \$60 Non-Member Price: \$85

Location: COR 203

Charlene Rydgren, P.O. Box 452 Malone, NY 12953 ; crydgren@gmail.com

The Next Generation Science Standards require students to use scientific and engineering practices and to apply crosscutting concepts to develop an understanding of disciplinary core ideas. How do we implement these shifts in our classroom? Participants will engage in a 3-Dimensional lesson followed by an analysis of the Science and Engineering Practices and Crosscutting Concepts involved in the lesson. The format of the NGSS will be explored; focusing on 3-Dimensional performance expectations. Time will be devoted to strategies for 3-D lesson design and story line development. Supplemental resources will be made available.

#### W02: Night Sky Network

Sponsor: Committee on Space Science and Astronomy

Time: 8:00 a.m.-12:00 p.m. Saturday

Member Price: \$110 Non-Member Price: \$135

Location: COR 404A

Joe Heafner, Catawba Valley Community College 2550 Highway 70 SE Hickory, NC 20602 ; heafner@gmail.com

Discover hands-on with astronomy activities that bring space science concepts to life for your students. From interactive scale models to aliens and supernova, these activities and demos will wow your students and bring these concepts to life. Come ready to play and learn. Leave with materials to use in your class plus interactive slide decks, connections to local astronomers, and easy to access additional activities.

#### W03: Preparing for Policy and Advocacy

Sponsor: AAPT

Time: 8:00 a.m.-12:00 p.m. Saturday

Member Price: \$60 Non-Member Price: \$85

Location: COR 103

Bethany Johns; bjohns@aip.org

Scott Franklin

Take advantage of the opportunity to meet with your Members of Congress while in Washington, DC, and educate them on the issues that are important to you. Congress must hear from you, their constituent, about the importance of science and education. Increasing the quality of science education is critical to helping the nation strengthen its global competitiveness by preparing a workforce for the 21st century. This workshop will train you on how to do a Congressional visit and will include how to effectively communicate with policy makers, as well as a briefing on current political news. This workshop is the final part of a three part series on science policy and how to engage. Two training webinars will be offered before the AAPT 2018 Summer Meeting on: 101 Science Policy and How To Engage With Policy Makers, which will include how to contact your Member of Congress to schedule a meeting.

#### **W04: PIRA Lecture Demonstrations I & II Condensed: Selections from the PIRA 200**

**Sponsor: Committee on Apparatus**

**Time: 8:00 a.m.-12:00 p.m. Saturday**

**Member Price: \$95                      Non-Member Price: \$120**

**Location: COR 204**

*Dale Stille, Rm 58 Van Allen Hall, Dept. of Physics and Astronomy, Univ. of Iowa, Iowa City, IA 52242 ; dale-stille@uiowa.edu*

*Sam Sampere, smsamper@syr.edu*

During this ½ day workshop, we will introduce you to the Physics Resource Instructional Association (PIRA) and the PIRA 200. Almost every demonstration one can think of has a catalog number within the Demonstration Classification System (DCS); we will introduce you to this system and the comprehensive bibliography that details journal articles and demonstration manuals for construction and use in the classroom. The PIRA 200 are the specific 200 most important and necessary demonstrations needed to teach an introductory physics course. We will also show a subset of approximately 50 demonstrations explaining use, construction, acquisition of materials, and answer any questions in this highly interactive and dynamic environment. Ideas for organizing and building your demonstration collection will be presented. We especially invite faculty members teaching introductory physics to attend. NOTE that this is a paperless workshop. All information and materials will be distributed on a USB thumb drive. A computer, tablet, or other device capable of reading a USB will be needed for note taking, or you can bring your own paper.

#### **W05: Research-based Approaches to Infusing Argumentation in Undergraduate Physics Learning and Problem Solving**

**Sponsor: Committee on Research in Physics Education**

**Co-sponsor: Committee on Physics in Undergraduate Education**

**Time: 8:00 a.m.-12:00 p.m. Saturday**

**Member Price: \$65                      Non-Member Price: \$90**

**Location: SEH 8750**

*Carina M. Rebello, Department of Physics and Astronomy, Purdue University 525 Northwestern Ave., West Lafayette, IN 47907; rebelloc@purdue.edu*

*N. Sanjay Rebello*

To positively impact higher education in STEM, post-secondary science educators have also begun to realize Next Generation Science Standards (NGSS Lead States, 2013) importance for college science teaching (Cooper et al., 2015). Scientific argumentation has been highlighted in NGSS as one of the key science and engineering practices. Studies have shown that embedding scientific argumentation in problems can enhance conceptual understanding and problem solving skills. Yet, students are seldom encouraged to justify or explain their solutions, reflect on their appropriateness, or consider alternatives. In this workshop we will share research-based approaches to infusing argumentation in introductory physics and provide evidence on the effectiveness of these approaches to improving learning and problem solving. We will briefly review literature on alternative frameworks and approaches to infusing argumentation in science. Participants will be encouraged to consider ways in which argumentation can be infused in their own classrooms and share these insights with others. We will discuss possible future directions that participants can embark upon to conduct research in their own settings about argumentation in physics. This workshop is supported in part by U.S. National Science Foundation grant 1712201. Opinions expressed are those of the authors and not necessarily those of the Foundation.

#### **W10: “Can We Have a Group Test?” Designing Collaborative, Active, Alternative Assessments for Physics Classes**

**Sponsor: Committee on Physics in High Schools**

**Co-sponsor: Committee on Teacher Preparation**

**Time: 8:00 a.m.-5:00 p.m. Saturday**

**Member Price: \$85                      Non-Member Price: \$110**

**Location: COR B103**

*Kelly O’Shea, 40 Charlton Street, New York, NY 10014; kellyoshea@gmail.com*

*Danny Doucette*

High school students need to learn how to construct explanations and design solutions using scientific practices, according to the NGSS. Lab practicums are an engaging and effective way for students to demonstrate their understanding. At the same time, students often learn and work in groups, and scientists also work in teams. How can we design assessments that challenge students to use their practical skills while also reflecting the social nature of scientific understanding? In this workshop, participants will work through collaborative practical exams, learn about different approaches to group and practical assessments, think through how to apply these assessments in their own classrooms, and have an opportunity to design and try out a practical assessment of their own. Although we hope that this workshop will be interesting to a wide audience, our target audience is high school teachers.

#### **W11: Using Arduino for High Altitude Ballooning**

**Sponsor: Committee on Educational Technologies**

**Co-sponsor: Committee on Apparatus**

**Time: 8:00 a.m.-5:00 p.m. Saturday**

**Member Price: \$110                      Non-Member Price: \$135**

**Location: COR 104**

*Kaye Smith, ksmith20@stkate.edu*

*Giovaini Organtini, Erick Agrimson, James Flaten*

Ever dream of doing science in space? Arduino microcontroller-based experiments and high-altitude weather balloons provide a low-cost and uncomplicated way to do science experiments in the stratosphere. This workshop will provide an introduction for those who wish to explore this exciting combination of platforms in their classroom and research. In the morning we will provide a brief introduction to using Arduino microcontrollers with emphasis on sensors appropriate to high-altitude ballooning research. In the afternoon we will cover the details of high-altitude ballooning and research opportunities in near-space. Throughout the day we will share ideas for projects that are hands on and student driven.

## W12: Physics Activities for the Life Sciences (PALS)

**Sponsor:** Committee on Research in Physics Education

**Co-sponsor:** Committee on Laboratories

**Time:** 8:00 a.m.-5:00 p.m. Saturday

**Member Price:** \$85      **Non-Member Price:** \$110

**Location:** COR 207

*Duane Deardorff, University of North Carolina at Chapel Hill, Campus Box 3255, Chapel Hill, NC 27599-3255; duane.deardorff@unc.edu*

*Alice Churukian, Colin Wallace, David Smith, Daniel Young*

Physics instructors are increasingly being asked to reform their teaching practices and use evidence-based instructional strategies to actively and intellectually engage their students. In this workshop, participants will gain first-hand experience implementing multiple collaborative learning activities that have been specifically designed for use in introductory physics for life science (IPLS) courses. Examples will include content from mechanics, electricity, magnetism, and optics, with each activity grounded in real-world applications to biological phenomena and/or medical practices. Participants will also gain a better understanding of student difficulties in IPLS-focused topics and be introduced to teaching methods aimed at addressing such issues.

## W13: Learn Physics While Practicing Science: Introduction to ISLE

**Sponsor:** Committee on Physics in Two-Year Colleges

**Co-sponsor:** Committee on Research in Physics Education

**Time:** 8:00 a.m.-5:00 p.m. Saturday

**Member Price:** \$88      **Non-Member Price:** \$113

**Location:** COR B112

*Eugenia Etkina, 10 Seminary Place, New Brunswick, NJ 08901; eugenia.etkina@gse.rutgers.edu*

*David Brookes, Gorazd Planinsic, Yuhfen Lin*

Participants\* will learn how to modify introductory physics courses at any level to help students acquire a good conceptual foundation, apply this knowledge in problem solving, and engage them in science practices. The framework for these modifications is Investigative Science Learning Environment (ISLE). We provide tested curriculum materials including: (a) The second edition of College Physics Textbook by Etkina, Planinsic and Van Heuvelen, the Physics Active Learning Guide and the Instructor Guide; (b) a website with over 200 videotaped experiments and questions for use in the classroom, laboratories, and homework; (c) a set of innovative labs in which students design their own experiments, and (d) newly developed curriculum materials that use LEDs to help students learn physics. During the workshop the participants will learn how to use the materials in college and high school physics courses to help their students learn physics by practicing it. We will focus on the connections of our materials with the NGSS and revised AP curriculum, specifically on the interplay of science practices and crosscutting concepts.

\*Please bring your own laptop to the workshop if you own one. If you do not own a computer, you will be paired with somebody who does.

## W14: Creating Mobile Physics Apps With Easy Java/JavaScript Simulations (EJS)

**Sponsor:** Committee on Educational Technologies

**Co-sponsor:** Committee on International Physics Education

**Time:** 8:00 a.m.-5:00 p.m. Saturday

**Member Price:** \$85      **Non-Member Price:** \$110

**Location:** SEH 2000

*Francisco Esquembre, Mathematics Department Facultad de Matemáticas, Universidad de Murcia, 30071 Murcia - SPAIN ; fem@um.es*

*Mario Belloni*

Easy Java/JavaScript Simulations (EJS) is a modelling and authoring tool that allows teachers with only basic programming skills to create sophisticated simulations in Java or JavaScript ([www.um.es/fem/EjsWiki](http://www.um.es/fem/EjsWiki)). The Open Source Physics collection at the AAPT-ComPADRE digital library hosts hundreds of these simulations which can be freely downloaded, inspected and, if desired, easily modified to match each teacher's needs. Now, EJS allows converting JavaScript simulations into individual Apps through simple usage of the IONIC platform ([ionicframework.com](http://ionicframework.com)). This means that the modified simulations can be converted into iOS or Android apps, or into Progressive Web Apps that run from browsers and are platform-savvy, including the possibility to access device hardware. This hands-on workshop will teach the basics of EJS, how to download and modify simulations from ComPADRE, and the process of converting a simulation into an independent App. Publishing in the Google Play or the App Store will be outlined, but not fully covered, since it requires individual subscriptions. Attendants will learn to test the App in their Android or iOS devices, and how to publish it from a Web server.

## W17: Integrated STEM Education: Infusing Engineering Design Practices in STEM Learning

**Sponsor:** Committee on Teacher Preparation

**Co-sponsor:** Committee on Physics in High Schools

**Time:** 1:00-5:00 p.m. Saturday

**Member Price:** \$80      **Non-Member Price:** \$105

**Location:** SEH 8750f

*Carina Rebello, Department of Physics and Astronomy, Purdue University, 525 Northwestern Ave., West Lafayette, IN 47906; rebelloc@purdue.edu*

*Lynn A. Bryan, Drew Ayres, N. Sanjay Rebello*

The Next Generation Science Standards (NGSS Lead States, 2013) and science standards of many states emphasize incorporation of engineering practices in science instruction. Drawing on the work of scholars who have inspired the meaningful integration of STEM disciplines at the K-12 level (e.g., Sanders, 2009; Sanders & Wells, 2010), we define integrated STEM as teaching and learning of content and practices of science and/or mathematics through integration of practices of engineering and engineering design of relevant technologies. In this workshop, we will share exemplars of recent CATALYST middle school curricula that integrate other STEM disciplines with physics learning (i.e. biology and physics). Finally, we will articulate a guiding conceptual framework for designing curricula for physics that integrates the learning of physics with other STEM disciplines. Participants will participate in design activities to emphasize engineering practices and have an

opportunity to strategize how they may wish to create integrated learning opportunities for their own physics classroom. Participants are requested to bring their own laptop computers. This workshop is supported in part by the Center for Advancing the Teaching and Learning of STEM (CATALYST), Purdue University.

### **W18: Introductory Labs for Thermal Physics**

**Sponsor:** Committee on Laboratories

**Time:** 1:00-5:00 p.m. Saturday

**Member Price:** \$72      **Non-Member Price:** \$97

**Location:** COR 203

*Kenn Lonnquist, 1875 Campus Delivery, CSU Physics; kennlonnquist@gmail.com*

*Mary Ann Hickman Klassen*

Whether your lab curriculum is ripe for an overhaul, well-established, or you are simply looking for exciting and innovative activities for the classroom, this workshop will provide new ideas to bring home to your institution. Presenters from colleges and universities across the United States will each demonstrate their approach to a favorite introductory lab exercise or two. This year's workshop will focus on labs for Thermal Physics. Attendees will have the opportunity to work with each instructor and their apparatus, and will have an opportunity to browse the equipment freely. Documentation will be provided for each experiment, with lab manuals, sample data, equipment lists, and construction or purchase information. This workshop is appropriate primarily for college and university instructional laboratory developers, but all instructors are welcome.

### **W19: Network Analysis in PER**

**Sponsor:** Committee on Research in Physics Education

**Time:** 1:00-5:00 p.m. Saturday

**Member Price:** \$60      **Non-Member Price:** \$85

**Location:** SEH Lehman

*Eric Brewe, 32 S. 32nd St., Disque Hall #816; eric.brewe@drexel.edu*

This workshop is intended to serve as an introduction to using Network Analysis in Physics Education Research. Network analysis is the analysis of relational data. In this workshop participants will consider how relational data differs in terms of data collection, cleaning, and analysis. This workshop will enable participants to explore analyses of pre-cleaned network data, or if participants have their own data we will facilitate working analyzing their own data. This hands-on approach will use pre-packaged software to explore network metrics that describe nodes and whole networks. Workshop participants will need to bring their own laptops, ideally with Gephi pre-installed. Gephi is an open source, cross platform, network analysis package that facilitates the visualization and analysis of network data.

### **W20: Modern Physics Labs on a Budget Using LEDs and Mixed Signal Processors**

**Sponsor:** Committee on Apparatus

**Co-sponsor:** Committee on Laboratories

**Time:** 1:00-5:00 p.m. Saturday

**Member Price:** \$80      **Non-Member Price:** \$105

**Location:** COR 204

*Mark Masters, Department of Physics, Purdue University Fort Wayne (PFW), 2101 Coliseum Blvd. E, Fort Wayne IN 46805; masters@ipfw.edu*

*Jacob Millspaw*

Participants will start with performing several investigations using LED's. First, participants will use a microcontroller to measure the I-V curve of several LED's and determine the Boltzmann constant (with assistance of a simple spectrograph). Second, participants will use LED's as very inefficient single photon avalanche photodiodes and do several counting and coincidence investigations. The participants will learn how to make (and take with them) several pieces of equipment to perform some modern physics investigations using LED's. In the process the participants will learn about how to use the mixed signal microcontrollers for other investigations as well.

### **W21: LIGO and Interferometers**

**Sponsor:** Committee on Apparatus

**Time:** 1:00-5:00 p.m. Saturday

**Member Price:** \$80      **Non-Member Price:** \$105

**Location:** COR 404A

*Dan Beeker, Physics Department, Indiana University, 727 E Third St., Bloomington, IN 47405; debeeker@indiana.edu*

*Ken Cecire, Kenneth.W.Cecire.1@nd.edu*

Learn about how the LIGO experiment uses interferometry to detect gravitational waves and study the result. We will put together an interferometer and do other hands-on activities with LIGO physics. Bring your laptop to work with LIGO data.

### **W22: Arduinos and Underwater ROVs**

**Sponsor:** Committee on Physics in Two-Year Colleges

**Co-sponsor:** Committee on Educational Technologies

**Time:** 1:00-5:00 p.m. Saturday

**Member Price:** \$180      **Non-Member Price:** \$205

**Location:** SEH B1270

*Gregory Mulder, Dept. of Physical Sciences, Linn-Benton Community College, 6500 Pacific Blvd. SW, Albany, OR 97321; mulderg@linnbenton.edu*

*Evan Thatcher, Heather Hill*

Microcontrollers are relatively inexpensive devices that you can program to collect data from a variety of sensor types and control exter-



nal devices such as motors and actuators. Microcontrollers can be used in a variety of classroom activities and student projects. We will focus our workshop on using an Arduino Microcontroller to construct a mini-underwater vehicle that will seek out to hover at a desired programmed depth. We will also discuss how our students use Arduinos for fun, research, underwater ROVs and general exploration. An optional pool-test of your mini-underwater vehicle will occur after the workshop at a nearby hotel pool. Note: you get to keep your mini ROV with Arduino. No previous microcontroller programming or electronics experience is required. You need to bring your own Windows, Mac, or Linux computer.

## **W24: Robotics for Diverse Equipment and Software Platforms**

**Sponsor: Committee on Physics in Pre-High School Education**

**Time: 8:00 a.m.-12:00 p.m. Sunday**

**Member Price: \$85                  Non-Member Price: \$110**

**Location: COR 104**

*Nina Daye, Trinity School, 4011 Pickett Road, Durham, North Carolina 27705; ninadaye@gmail.com*

*Daniel Kophazi*

This workshop will provide interested teachers with an introduction of how to use robotics to teach science concepts in introductory physics and physical science classes. Robots are a natural way to apply physics concepts to daily life. These materials can be used in a class setting or as an extra-curricular activity for enrichment. We will provide additional information about various robotics competitions available for students. This workshop will be useful for middle schools, high schools and Introductory college classes.

## **W25: Coding Integration in High School STEM Courses**

**Sponsor: Committee on Physics in High Schools**

**Co-sponsor: Committee on Educational Technologies**

**Time: 8:00 a.m.-12:00 p.m. Sunday**

**Member Price: \$30                  Non-Member Price: \$55**

**Location: SEH B1270**

*Chris Orban, Department of Physics, 191 W Woodruff Ave., Columbus, OH 43210; orban.14@osu.edu*

*Prof. Richelle Teeling-Smith, University of Mt. Union Department of Physics*

Ever wondered how to integrate a little bit of coding into a high school physics class without overwhelming your students or taking up lots of class time? This hands on workshop will provide an overview of simple, conceptually-motivated exercises where students construct games like asteroids and angry birds using a free in-browser editor that works great on chromebooks or whatever devices you have. Following that we will show you how to use [stemcoding.osu.edu](http://stemcoding.osu.edu) which is a free "learning management system" that is designed to facilitate using coding activities in sizable classes. This framework also includes assessment questions designed to probe whether students are building their conceptual knowledge as they complete the activities. We will share with you a full set of lesson guides and solutions for over 17 different simple coding activities for high school physics and physical science, all of which produce PhET-like interactives. If you have enjoyed seeing coding tutorial videos on the STEMcoding youtube channel (<http://go.osu.edu/STEMtube>) here is your chance to do a deep dive! The STEMcoding project is led by Prof. Chris Orban from Ohio State Physics and Prof. Richelle Teeling-Smith in the physics department at the University of Mt. Union. The STEMcoding project is supported in part by the AIP Meggers Project Award.

## **W26: Designing and Assessing Informal Physics Programs**

**Sponsor: Committee on Science Education for the Public**

**Co-sponsor: Committee on Research in Physics Education**

**Time: 8:00 a.m.-12:00 p.m. Sunday**

**Member Price: \$60                  Non-Member Price: \$85**

**Location: SEH 8750**

*Katie Hinko, Michigan State University, Holmes Hall 919 E. Shaw Ave., East Lansing, MI 48825; hinko@msu.edu*

*Claudia Fracchiolla*

This workshop is for attendees who are looking to develop an informal physics program, or who already facilitate an informal physics program, to reflect on design and assessment. The focus will be on big picture planning - the intent is not to showcase specific physics demonstrations or apparatus but to establish a broader plan of action for the design of activities that meet the goals and needs of the programs. In the first part of the workshop, you will identify needs in physics education in local communities, consider how to partner with community organizations, and determine the goals of existing or new programs. Attendees will spend significant time developing their ideas and getting feedback from fellow attendees and workshop organizers. The second part of the workshop includes a discussion of challenges in assessing informal physics programs, how to develop a research agenda, and planning for assessment. Attendees will consider the best tools and practices for their program. Additionally, in this workshop you will connect with other people interested in research-driven informal physics programs to build community and collaboration. Workshop attendees will take away ideas about how to leverage effective design and assessment of informal settings towards increased resources and support.

## **W27: Integrating Modern Physics into the High School Physics Curriculum**

**Sponsor: Committee on Apparatus**

**Co-sponsor: Committee on Modern Physics**

**Time: 8:00 a.m.-12:00 p.m. Sunday**

**Member Price: \$60                  Non-Member Price: \$85**

**Location: COR B103**

*Jeff Rodriguez, 8593 Coran Drive, Cincinnati, OH 45255; jeffrodriguez@foresthills.edu*

*Silvia Bravo, Martin Shaffer*

Do you find it difficult to add modern physics into your high school physics curriculum at the end of the school year? Are you looking for activities closer to the scientific cutting edge during the school year? Why not try to integrating modern physics topics and data from recent experiments into your current curriculum? Come join us and let's work through multiple activities from modern physics experiments that apply and integrate kinematics, momentum, energy, ohm's law, and more fundamental physics that we teach every day.

## W28: PIRA: Procuring Apparatus for Outreach Shows

**Sponsor:** Committee on Apparatus

**Time:** 8:00 a.m.-12:00 p.m. Sunday

**Member Price:** \$90

**Non-Member Price:** \$115

**Location:** SEH Lehman

*Dave Maiullo, Department of Physics/Rutgers 136 Frelinghuysen Road Piscataway, NJ 08854 ; maiullo@physics.rutgers.edu*

*Sam Sampere, Dale Stille*

This workshop will be a primer on how to procure apparatus for effective physics outreach. We will review the ideal demos for effective outreach, list and review effective and ongoing outreach programs, how to find sources of funding for outreach demos, and where to purchase and how to produce outreach demos. Participants will leave with at least one new demo for their outreach!

## W29: 3D Solid Modeling Workshop

**Sponsor:** Committee on Apparatus

**Co-sponsor:** Committee on Educational Technologies

**Time:** 8:00 a.m.-12:00 p.m. Sunday

**Member Price:** \$61

**Non-Member Price:** \$86

**Location:** COR 404A

*Paul Fratiello, Eckerd College, 4200 54th Ave. S., St. Petersburg, FL 33711; fratiepj@eckerd.edu*

Are you interested in 3D printing? Designing demo or lab equipment on the computer? The first step is learning the basics of 3D solid modeling. In this half day workshop, you will learn how to create simple 3D solid models. We will be using Onshape, a free to educator/student software that resides completely in the cloud. Accessing Onshape is as easy as logging into your e-mail. Since it is in the cloud, no need for downloading software or deal with updates. It is also easy to share files with others for troubleshooting help. Bring your own laptop and mouse.

## W30: Using Social Psychological Interventions to Improve Learning of All Students

**Sponsor:** Committee on Women in Physics

**Co-sponsor:** Committee on Research in Physics Education

**Time:** 8:00 a.m.-12:00 p.m. Sunday

**Member Price:** \$65

**Non-Member Price:** \$85

**Location:** COR 103

*Emily Marshman, University of Pittsburg; emm101@pitt.edu*

*Zeynep Kalender, Timothy Nokes-Malach, Christian Schunn, Kevin Binning, Chandralekha Singh*

Instructors often focus on content and pedagogical approaches to improve student engagement and learning in physics courses. However, students' motivational characteristics can also play an important role in their engagement and success in physics. For example, students' sense of belonging in a physics class, their self-efficacy, and views about whether intelligence in physics is "fixed" or "malleable" can affect engagement and learning. These types of concerns can especially impact the learning outcomes of women and other underrepresented students in the physics classes and stereotype threats can exacerbate these issues while learning physics. In this workshop, we will discuss prior research studies that show how different types of social psychological interventions (e.g., social belonging and growth mindset) have improved the motivation and learning of all students, especially women and underrepresented minorities in STEM fields. These interventions include providing data to students about how intelligence is malleable and one can become an expert in a discipline by working hard in a deliberate manner, sharing with students examples of testimonies of past students with diverse backgrounds who struggled initially but then succeeded by working hard and using deliberate practice, asking students to write a letter to a future student about how they can succeed in physics and view struggling as a stepping stone to succeeding and giving students an opportunity to share their concerns with peers. We will discuss how these interventions can be adapted and implemented in physics classes. We will also describe and have participants reflect upon a social belonging and growth mindset intervention that we have incorporated in introductory physics courses and initial findings from the intervention. The participants will also have the opportunity to adapt one of the interventions for use in their own physics courses in small groups and act out the intervention with the workshop participants in other groups acting as introductory physics students. Suggestions and feedback on the interventions chosen and acted out during the workshop will be provided from workshop leaders and other participants. The types of interventions discussed in this workshop are short, requiring less than one hour of regular class or recitation time even though they have the potential to impact student outcomes significantly—especially for women and other underrepresented students in physics classes. This workshop is suitable for K-12 and college instructors and teaching assistants (both graduate and undergraduate). If you would like to send me the details that you get when you upload these things, I can take a look to see that everything is fine. Thanks again for everything! I am very sorry for increasing your work.

## W32: Fun and Engaging Labs

**Sponsor:** Committee on Physics in High Schools

**Co-sponsor:** Committee on Teacher Preparation

**Time:** 8:00 a.m.-12:00 p.m. Sunday

**Member Price:** \$60

**Non-Member Price:** \$85

**Location:** COR B112

*Wendy Adams, Colorado School of Mines, 1500 Illinois St., Golden, CO 80401; wendy.adams@colorado.edu*

*Duane Merrell*

In this workshop we will share many labs that are suitable for both high school and introductory college physics. The labs are challenging but not too difficult and, leave plenty of room for creativity! We have found success by limiting the goals for the labs to: 1. Fun and engaging, 2. Built in student choice, 3. Related to this week's material. The labs are effective at engaging the students in problem solving and conceptual understanding. Merrell used this type of lab as a high school teacher and physics quickly became one of the most popular classes in the school. Adams, inspired by Merrell, has found that her college students no longer rush to leave, and in some cases stay to see how other groups do even after they've turned in their lab write up for the day! This workshop will allow you to try out these labs for yourself.

### **W33: PICUP: Integrating Computation into Undergraduate Physics**

**Sponsor:** Committee on Physics in Undergraduate Education

**Co-sponsor:** Committee on Educational Technologies

**Time:** 8:00 a.m.-12:00 p.m. Sunday

**Member Price:** \$80

**Non-Member Price:** \$105

**Location:** COR 204

*Marie Lopez del Puerto, mlpuerto@stthomas.edu*

*Kelly Roos, Danny Caballero, Norman Chonacky*

In this workshop we will discuss the importance of integrating computation into the physics curriculum and will guide participants in discussing and planning how they would integrate computation into their courses. The PICUP partnership has developed materials for a variety of physics courses in a variety of platforms including Python/VPython, C/C++, Fortran, MATLAB/Octave, Java, and Mathematica. Participants will receive information on the computational materials that have been developed, will discuss ways to tailor the materials to their own classes, and will learn about opportunities that are available to receive additional support through the PICUP partnership. PLEASE BRING A LAPTOP COMPUTER WITH THE PLATFORM OF YOUR CHOICE INSTALLED. This workshop is funded by the National Science Foundation under DUE IUSE grants 1524128, 1524493, 1524963, 1525062, and 1525525. This workshop is funded by an NSF grant. The participant will pay up front for the workshop during registration and receive a refund after the workshop is completed in the amount of \$60. The total cost of the workshop to each participant is \$20 for AAPT members and \$45 for non-members of AAPT.

### **W34: Fun, Engaging, and Effective Labs and Demos in Electricity, Magnetism and Optics with Clickers, Video Analysis, and Computer-based Tools**

**Sponsor:** Committee on Research in Physics Education

**Co-sponsor:** Committee on Educational Technologies

**Time:** 8:00 a.m.-12:00 p.m. Sunday

**Member Price:** \$75

**Non-Member Price:** \$100

**Location:** COR 203

*David Sokoloff, 1430 E 43rd Ave., Eugene, OR 97405; sokoloff@uoregon.edu*

*Ronald Thornton, Priscilla Laws*

RealTime Physics and Interactive Lecture Demonstrations have been available for over 15 years—so what's new? Participants in this workshop will have hands-on experience with some of the activities in RTP and ILD using clickers, video analysis and computer-based tools to teach electricity, magnetism and optics. These active learning approaches for lectures, labs, and recitations (tutorials) are fun, engaging and validated by physics education research (PER). Research results demonstrating the effectiveness of these curricula will be presented. The following will be distributed: Modules from the Third Edition of RTP, and the ILD book.

### **W35: STEP UP 4 Women**

**Sponsor:** Committee on Women in Physics

**Co-sponsor:** Committee on Physics in High Schools

**Time:** 8:00 a.m.-12:00 p.m. Sunday

**Member Price:** \$60

**Non-Member Price:** \$85

**Location:** COR 207

*Rebecca Vieyra, 225 C St. SE Apt. B; rvieyra@aapt.org*

Support gender equity in physics education through active strategies and discussions. Come to this workshop to learn how to be a part of a national campaign for high school physics teachers and their students, STEP UP for Women (Supporting Teachers to Encourage Pursuit of Undergraduate Physics for Women). During this workshop, learn about gender representation in physics in the U.S. and around the world, and engage in active strategies and two specific lessons that are demonstrated to enhance the physics identity of young women. If only one-third of high school physics teachers was able to recruit an interested young woman to a physics undergraduate program, gender imbalance upon enrollment would be offset. Undergraduate faculty have a special role to welcome and retain these young women. Whoever you might be, be a part of the change! (This workshop is fully funded by NSF #1720869. Participants who complete the workshop may seek full reimbursement of their workshop registration fee.)

### **W38: Fostering Inclusivity in Physics: Resources, Strategies, and Interventions**

**Sponsor:** Committee on Women in Physics

**Co-sponsor:** Committee on Diversity in Physics

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$60

**Non-Member Price:** \$85

**Location:** SEH Lehman

*Mike Vigna, vignalm@oregonstate.edu*

*Mackenzie Lenz, Kelby Hahn*

This workshop aims to help physicists and physics educators learn how to create inclusive environments in their classrooms, schools, and/or departments. The tools and strategies developed in this workshop will be informed by intersectional feminism, feminist science studies, and physics education research. In the first half of this workshop, we will explore different ways institutional and structural discrimination manifest in physics institutions and communities. We will also discuss ways to anticipate and mitigate these discriminations and the problems they create. In the second half of the workshop, we will practice identifying and intervening in instances of discrimination and bias. This practice will help participants become knowledgeable about and comfortable with addressing these issues as they arise in everyday situations.

### W39: Interdisciplinary Instruction in Biological Physics

**Sponsor:** Committee on Physics in Undergraduate Education

**Co-sponsor:** Committee on Graduate Education in Physics

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$60

**Non-Member Price:** \$85

**Location:** COR 101

*Phillip Nelson, Physics, Univ Penn, 209 South 33d St., Phila PA 19104; nelson@physics.upenn.edu*

Physics departments must constantly develop up-to-date courses that can attract both majors and non-majors. Specifically, students from Bioengineering, Materials, Chemistry, Chem.E., Biochemistry, Biophysics (and even Physics) are keenly interested in biophysical topics. There is also a growing cohort of premedical students in these majors who are willing to go beyond standard first year text material. Many faculty find such interdisciplinary instruction scary, at first, so there is much to discuss. The session will include: \* Discussion of inexpensive in-class demos, with detailed how-to documentation. \* Discussion of collaborative tasks, especially getting students up and running with computer programming very fast, in a course not explicitly dedicated to computation. \* Science tutorials, especially on the recent revolution in light imaging (superresolution, two-photon, etc), stochastic simulation, dynamical systems, visual neuroscience. \* Discussion of project-based learning, including pairing students across disciplines as partners. Participants should bring a laptop computer to the session. Some funds will be available to offset registration fees.

### W40: Tying Activity Based Physics Bits & Pieces to NGSS

**Sponsor:** Committee on Physics in High Schools

**Co-sponsor:** Committee on Educational Technologies

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$80

**Non-Member Price:** \$105

**Location:** COR 203

*Steve Henning, 52 Dick Drive, Worcester, MA 01609; physfsh@gmail.com*

*Maxine Willis*

This hands-on workshop is designed for AP, IB and honors physics teachers interested in engaging their students in inquiry-based active learning based on the award winning Workshop Physics curriculum at Dickinson College. Teachers will work with activities based on PER and NGSS in mechanics, rotational motion, waves and circuits selected from the Activity-Based Physics High School Edition. How to use pre- and post-testing assessments will be a part of the workshop. The curricula uses computers for data collection and analysis and allows students to learn physics by doing physics. In addition to Workshop Physics, the workshop will include units from Interactive Lecture Demonstrations, Physics with Video Analysis and Interactive Video Vignettes. Activities that tie into NGSS will be highlighted and discussed. The data acquisition software is compatible with both Mac and Windows computers and is supported with set-up files by PASCO and Vernier. Participants will receive copies of supporting texts in addition to Teaching with the Physics Suite.

### W41: Intermediate and Advanced Labs

**Sponsor:** Committee on Laboratories

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$85

**Non-Member Price:** \$110

**Location:** SEH B1270

*Jeremiah Williams, 225 N. Fountain Ave., Physics Department, Wittenberg University, Springfield, OH 45504; jwilliams@wittenberg.edu*

This workshop is appropriate for college and university instructional laboratory developers. At each of five stations, presenters will demonstrate an approach to an intermediate or advanced laboratory exercise. Each presenter will show and discuss the apparatus and techniques used. Attendees will cycle through the stations and have an opportunity to use each apparatus. Documentation will be provided for each experiment, with sample data, equipment lists, and construction or purchase information.

### W42: Getting Students to Think Critically in Intro Labs

**Sponsor:** Committee on Research in Physics Education

**Co-sponsor:** Committee on Laboratories

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$62

**Non-Member Price:** \$87

**Location:** COR B103

*Natasha Holmes; ngholmes@cornell.edu*

*Joss Ives, Emily Smith*

In this hands-on, minds-on workshop, we'll exploring new research-based strategies for getting students to think critically in intro physics labs. We'll explore methods of teaching scientific practices such as uncertainty and data analysis, modeling, and experimental design. We will focus on a strategy that uses cycles of comparisons and decision making to expose students to the creativity and excitement of physics experimentation, the nature of measurement, and more. We aim for participants to leave the workshop with tools, ideas, and structure to implement the approach in their own courses.

### W43: Effective Practices for Final Projects in Undergraduate Physics Lab Courses

**Sponsor:** Committee on Laboratories

**Co-sponsor:** Committee on Apparatus

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$60

**Non-Member Price:** \$85

**Location:** SEH 8750

*Dimitri Dounas-Frazer, Department of Physics, University of Colorado Boulder, Boulder, CO 80309-0390; dimitri.dounasfraser@colorado.edu*

*Laura Ríos, Heather Lewandowski, Benjamin Pollard*

Lab courses provide exciting opportunities for instructors and students alike to engage in authentic physics experimentation. During this half-day interactive workshop, lab instructors and education researchers will share creative teaching ideas with one another. In particular, we will discuss teaching practices that are known to support students' development of competence with modeling, troubleshooting, and scientific communication. We will also discuss how to design projects and learning environments that result in students feeling ownership of their work and proud of their outcomes. The goal of this workshop is for all participants to walk away with concrete strategies and design principles that they can incorporate into their next lab course.

#### **W44: Examining the Relationships among Intuition, Reasoning, and Conceptual Understanding in Physics**

**Sponsor:** Committee on Research in Physics Education

**Co-sponsor:** Committee on Physics in Undergraduate Education

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$60

**Non-Member Price:** \$85

**Location:** COR 103

*Andrew Boudreaux, Western Washington University, 516 High St., Bellingham, WA 98225-9164; andrew.boudreaux@wwu.edu*

*Mila Kryjevskaja, Mackenzie Stetzer, Beth Lindsey, Paula Heron*

Teachers of physics commonly expect their students to draw on formal physics knowledge to construct chains of reasoning that start from established principles and lead to well-justified predictions. If exam performance does not match such thinking patterns, it is natural to conclude that students either do not possess the requisite conceptual understanding, or perhaps that they lack the reasoning ability needed to chain the ideas together. An emerging body of cognitive science research, however, suggests an alternate explanation: students may "abandon" formal reasoning in favor of ideas that are more intuitively appealing in the moment. As yet, not much is known about how intuition, reasoning, and conceptual understanding interact as a student learns new physics. Nevertheless, insight into these relationships is important for both researchers and instructors. In this workshop, participants will explore these relationships by examining student responses to a variety of assessment tasks. The focus will be on collaborative analysis and interpretation of student data, and on discussion of the implications for classroom instruction in physics.

#### **W45: An Introduction to Race, Ethnicity, and Equity in Physics Education**

**Sponsor:** Committee on Diversity in Physics

**Co-sponsor:** Committee on Research in Physics Education

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$65

**Non-Member Price:** \$90

**Location:** COR 207

*Katemari Rosa, Rua Barao de Loreto, 65/303, Salvador, Bahia, Brazil, 40150-270; katemari@gmail.com*

*Abhilash Nair, Vashti Sawtelle, Chandra Turpen*

This workshop focuses on race, ethnicity, and equity in the context of physics education. We especially encourage those that may feel novice in talking about race and ethnicity to attend but welcome everyone who is interested in exploring this area as well. We will support participants to examine educational spaces through the lenses of race and ethnicity. We will also consider how race and ethnicity play a role in systemic issues affecting physics education more broadly. Topics to be explored will be guided by participant input and may include, but are not limited to: identity, culture, privilege, microaggressions, implicit bias, and colorblind rhetoric. We will engage in group conversations, self-reflection, and explore possibilities for action within our own institutional contexts

#### **W47: Physics of Toys**

**Sponsor:** Committee on Science Education for the Public

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$65

**Non-Member Price:** \$90

**Location:** COR 204

*Beverly Taylor, Miami University Hamilton, 1601 University Blvd., Hamilton, OH 45042; taylorba@miamioh.edu*

This hands-on workshop is designed for teachers at all levels in search of fun physics demonstrations, lab experiments, and interactive materials through the use of ordinary children's toys. More than 60 toys will be demonstrated and the physical principles related to these toys will be discussed. This workshop will concentrate on toys that illustrate the concepts of kinetic and potential energy, linear and angular momentum, electricity, magnetism, pressure, and temperature. You will have the opportunity to participate in both qualitative and quantitative investigations using toys. The workshop leaders have found that toys can be utilized at all grade levels from kindergarten through college by varying the sophistication of the analysis. These same toys can also be used for informal presentations to public groups of all ages, whether children or adults.

#### **W48: Improving the Pedagogical Content Knowledge of Teaching Assistants and Instructors**

**Sponsor:** Committee on International Physics Education

**Co-sponsor:** Committee on Graduate Education in Physics

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$60

**Non-Member Price:** \$85

**Location:** SEH 2000

*Alexandru Maries, Assistant Professor – Educator 442 Geo-Phys, 7 Department of Physics, University of Cincinnati, 345 Clifton Ct., Cincinnati, OH 45221-0011; mariesau@ucmail.uc.edu*

*Chandralekha Singh*

In order to help students learn physics and develop their problem solving and reasoning skills, physics instructors and teaching assistants should not only have content knowledge of physics but also be versed in pedagogy in order to bridge the gap between teaching and learning. The knowledge of common student difficulties with various physics concepts is one aspect of what Shulman coined as "pedagogical content knowledge". In this workshop, we will explore the common difficulties of introductory physics students in mechanics and electricity and magnetism and the extent to which instructors and teaching assistants are aware of it. Participants will identify common alternate conceptions of introductory physics students on some physics questions in mechanics and electricity and magnetism and compare

their responses with what the data suggest are the common difficulties in those contexts. In addition, participants will discuss productive approaches to integrate this knowledge into their pedagogical design to help their introductory physics students develop a robust knowledge structure. This workshop is suitable for K-12 and college instructors as well as teaching assistants (both graduate and undergraduate).

#### **W49: Demo Kit in a Box: Optics**

**Sponsor:** Committee on Science Education for the Public

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$85      **Non-Member Price:** \$110

**Location:** COR B112

*Steve Lindaas, Dept. of Physics and Astronomy, Minnesota State University Moorhead, 1104 7th Avenue South, Moorhead MN 56563; lindaas@mnstate.edu*

*Adam Beehler*

This workshop is packed with demos and activities suitable for all ages. Are you looking for easy ways to infuse inquiry into your classroom? Don't have a demo manager? We will help you establish having several small demos conveniently packed into one box, ready for the classroom at any moment. You may bring your box to your class and use the demos to highlight lecture points, or use them when a student asks a question. Use a "Just-In-Time" teaching approach but with a demo twist! We will show you how to pack small demo kit boxes that pack a large instructional punch. The demo focus this summer is optics (cool visuals are likely to be involved). Participants will leave with a lot of demos!

#### **W51: Field Trip to the Air and Space Museum**

**Sponsor:** Committee on History and Philosophy in Physics

**Time:** 1:00-5:00 p.m. Sunday

**Member Price:** \$0      **Non-Member Price:** \$0

**Location:** offsite

*Ekaterina Michonova, Erskine College, 2 Washington St., Box 338, Due West, SC 29639-338; michonova@erskine.edu*

*Space Committee*

AAPT SM18 attendees will be given the opportunity to attend a field trip to the National Air and Space Museum in Washington, DC. Attendees will metro from the Washington Renaissance to the Air and Space Museum.

## **Find some quiet space during the meeting!**



### **Quiet Room (Meeting Room 1)**

#### **Hours:**

Saturday – 7 a.m. to 10 p.m.

Sunday – 7 a.m. to 10 p.m.

Monday – 7 a.m. to 10 p.m.

Tuesday – 7 a.m. to 10 p.m.

Wednesday – 8 a.m. to 10 p.m.

## Bus schedule for workshops

METRO cards will be provided, except for Sunday morning, since the METRO does not start until 8:00 a.m.

### Sunday, July 29

Buses departing the Renaissance DC  
Downtown (from the K St. entrance)

- 7:15 a.m.
- 7:25 a.m.
- 7:40 a.m.

Buses will depart from the Cambria Hotel:  
7:35 a.m.

### Transportation (Washington DC Metro)

Board the **Red Line** train at Gallery Place/Chinatown Station (616 H Street, NW)

Take the **Red Line** towards Shady Grove to Metro Center (one stop)

Depart the train at Metro Center and board the **Blue Line** train towards Franconia-Springfield

Depart the train at Foggy Bottom GWU (four stops)

This trip will take approximately 15 minutes each way.



Monday • 10:40 a.m. Gskyer Telescope



Monday • 3:40 p.m. Google Day Dream View - VR Headset

## Exhibit Hall Raffles

### Monday and Tuesday

Gskyer Telescope, AZ70700

Force 1 Drone w/ camera

Amazon Echo

Google Day Dream View - VR Headset

(Must be present to win)  
Grand Ballroom North/Central

**Purchase tickets at  
Registration desk!**



Tuesday • 10:20 a.m. Force 1 Drone with camera



Tuesday • 3:40 p.m. Amazon Echo

## Session AA: PER: Instructor Support, Professional Development, Program and Institutional Change

Location: Marriott Marquis - Chinatown Room Sponsor: AAPT/PER Time: 8:30–10:30 a.m. Date: Monday, July 30 President: Mary Bridget Kustusch

### AA01: 8:30-8:40 a.m. The Physics Graduate Experience: Retention, Happiness, and Productivity

Contributed – Sara Mueller, The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; mueller.352@osu.edu

Christopher D. Porter, Amber B. Simmons, Alison C. Koenka, Andrew Heckler, The Ohio State University

To better understand the attrition rate of Physics PhD students, our multi-year study, still in its initial stages, aims to describe the various pathways students navigate while enrolled in the physics PhD program at Ohio State University. We distinguish students by their primary responsibility at the time of surveying and sort them into three distinct subpopulations. First-year graduate students are focused on completing core coursework. Pre-candidacy second and third year students have their attention stretched between finishing coursework requirements and beginning research activities. Whereas post-candidacy students are primarily research, thesis, and employment-oriented. We measure students' PhD satisfaction and rank their productivities by self-reported achievements of traditional graduate school milestones. Here we present preliminary results describing some of the common pathways taken by students, and present a multiple-regression model that suggests a student's sense of belonging, experienced cost, and recognition in the PhD program play critical roles in PhD satisfaction.

### AA02: 8:40-8:50 a.m. PER PhDs & Physics Bachelor's Degrees Awarded

Contributed – Susan White, AIP Statistical Research Center, 1 Physics Ellipse, College Park, MD 20740; swhite@aip.org

Gary White, GWU / AAPT

In the February 2017 issue of *The Physics Teacher*, I examined the correlation between physics departments that did and did not offer PhD with a PER specialization and their physics bachelor's degree production. We used the 2004, 2005, 2014, and 2015 print issues of GradSchoolShopper to determine whether or not a department offered the PER specialization. We found that PhD departments that had a PER specialization for 10 years produced more physics bachelor's degree recipients than PhD departments which did not, even after accounting for department size using FTE faculty members. In this talk, we will dig into the data more deeply than we were able to in a monthly column.

### AA03: 8:50-9:00 a.m. STEM DBER Alliance

Contributed – Charles Henderson, Western Michigan University, WMU Physics, Kalamazoo, MI 49008-5444; charles.henderson@wmich.edu

Scott Franklin, Rochester Institute of Technology

Noah Finkelstein, University of Colorado Boulder

Discipline-based Education Research (DBER) is now embedded in most STEM disciplines. Situating within a discipline brings a number of important affordances to individual researchers, including access to professional member societies and integration into departments. While productive for some research questions, this approach has prevented progress on larger cross-cutting research topics that intrinsically span multiple disciplines, and prevented the formation of a broad community to establish norms and standards. The STEM DBER Alliance (DBER-A) was recently initiated and has convened two workshops that brought representatives of the STEM DBER communities together to identify common needs and cross-disciplinary research priorities. In this presentation we will discuss the need for DBER-A, outcomes of the workshops and other current activities, as well as our vision for the future. We hope to spur broader conversations within the PER community about how PER might contribute to and benefit from DBER-A.

### AA04: 9-9:10 a.m. Building on Institutional Efforts: Results from the TRESTLE Project\*

Contributed – Stephanie Chasteen, University of Colorado Boulder, 247 Regal St., Louisville, CO 80027; stephanie.chasteen@colorado.edu

The University of Colorado Boulder has benefited from decades of programs aimed at STEM education improvements, including the Science Education Initiative (SEI; 2005-2014), initiated by Carl Wieman. The SEI provided funding and training for postdoctoral fellows to partner with faculty in STEM departments on course transformation. In 2015, seven institutions joined forces to apply the SEI model across a variety of institutional contexts, creating the Transforming Education, Stimulating Teaching and Learning Excellence (TRESTLE; <http://trestlenetwork.org>) network. At CU Boulder, the TRESTLE project has provided a mechanism for faculty involved in the former SEI to continue to engage in educational transformation, and to involve faculty newer to this work, through course transformation awards and faculty learning communities. In this talk I will share initial results of the TRESTLE project at CU Boulder and their implications for supporting sustained faculty engagement in educational improvements.

\*This material is based upon work supported by the National Science Foundation under Grant No. 1525331.

### AA05: 9:10-9:20 a.m. Capacity Building as an Orienting Goal for Departmental Action Teams

Contributed – Joel C. Corbo, University of Colorado Boulder, 860 35th St., Boulder, CO 80303; joel.corbo@colorado.edu

Gina M. Quan, University of Colorado Boulder

Courtney Ngai, Mary E. Pilgrim, Colorado State University

Daniel Reinholz, San Diego State University

Much of faculty development around teaching has focused on activities like disseminating curriculum, teaching the implementation of research-based instructional strategies, or (more rarely) cultivating reflective teachers. In our work with Departmental Action Teams (DATs), we take an alternative approach to faculty (and student and staff) development by focusing on individual and group capacity-building: we ask, "What are the ways in which DAT participants, both as individuals and as a group, need to grow in order to effect change in their departments?" Here, we define "capacity" as a collection of skills, knowledge, and other resources that are useful for accomplishing a particular outcome, which in the case of a DAT is departmental change around undergraduate education. We focus on several capacities useful for DATs that have not typically been addressed in the faculty development literature, including understanding change processes, understanding local departmental contexts, and being effective collaborators.

### AA06: 9:20-9:30 a.m. Research on University Faculty's Reasoning about how Departments Change

Contributed – Gina M. Quan, University of Colorado Boulder, 393 UCB, Boulder, CO 80309; gina.m.quan@gmail.com

Joel C. Corbo, University of Colorado Boulder

Courtney Ngai, Mary E. Pilgrim, Colorado State University



*Daniel Reinholz, San Diego State University*

Research on institutional change says that effective change agents are able to flexibly reason with multiple models for change, depending on their local context and their goals. However, little is known about what it looks like for individuals to draw on and reason with different change models in-the-moment. Within interviews, we invited STEM faculty to discuss specific changes in their department and the process of change in general. This work is part of an ongoing study to understand how to support departmental change through Departmental Action Teams (DATs). Our preliminary analyses suggest that faculty's ideas about change are highly varied and context-dependent. This work will lead to a better understanding of how productive lines of reasoning can be leveraged in DATs and other faculty communities that are trying to create positive change.

#### **AA07: 9:30-9:40 a.m. The Nature of Teacher Talk in Faculty Online Learning Communities**

*Contributed – Alexandra C. Lau, University of Colorado Boulder, Department of Physics, 390 UCB, Boulder, CO 80309; alau693@gmail.com*

*Melissa H. Dancy, University of Colorado Boulder*

*Charles Henderson, Western Michigan University*

*Andy Rundquist, Hamline University*

The New Faculty Workshop Faculty Online Learning Community (NFW-FOLC) supports approximately 10 NFW participants in the year following their participation in the workshop. Members of the NFW-FOLC meet biweekly via a video conferencing platform to hear from experienced practitioners of various teaching techniques as well as to discuss their teaching with their peers. During some meetings, participants have an extended period of time to share a “State of the Classroom” update with their cohort and gather feedback on challenges they are encountering. One of the main goals of the NFW-FOLCs is to promote sustained and high-quality implementation of Research Based Instructional Strategies. It is thus important for us to know how FOLC cohort members are talking about their teaching and responding to each other's talk. In this presentation we report on our analysis of the quality and characteristics of “State of the Classroom” updates from a selection of NFW-FOLC members.

#### **AA08: 9:40-9:50 a.m. Variations in Conversational Routines Across Two Faculty Communities**

*Contributed – Adriana Corrales,\* San Diego State University, CRMSE, 6475 Alvarado Road, Ste 206, San Diego, CA 92120; acorrales2@sdsu.edu*

*Chandra Turpen, University of Maryland*

*Fred Goldberg, San Diego State University*

*Meghan Clemons, Tennessee Technological University*

*Edward Price California State University San Marcos*

Across educator professional development efforts, there is significant momentum around building professional learning communities. More research however is needed on how the design and emergent norms of such communities enable or constrain particular learning opportunities for educators. In this presentation, we share a comparative analysis of the conversations unfolding in two distinct faculty communities (associated with the Next Generation Physical Science and Everyday Thinking Faculty Online Learning Community project [1]). We choose to focus on moments in their online conversations when seemingly similar issues or topics arise (e.g. concerns about pacing). By comparing these moments, we demonstrate important differences in how the instructional problem is posed and in the conversational routines across these two groups. We illustrate how these differences open up and close off opportunities to learn [2].

\*Sponsored by Fred Goldberg [1] Work supported by NSF Grant 1626496 [2] I. S. Horn & B. D. Kane (2015). *Journal of the Learning Sciences*, 24(3), pp. 373-418.

#### **AA09: 9:50-10:00 a.m. Instructional Dilemmas Around Energy Representations: Learning Potential in Faculty Communities**

*Contributed – Fred M. Goldberg, San Diego State University, CRMSE, 6475 Alvarado Road, Ste 206, San Diego, CA 92120; fgoldberg@mail.sdsu.edu*

*Chandra Turpen, University of Maryland*

*Adriana Corrales, San Diego State University*

*Ed Price, California State University San Marcos*

*Melissa Dancy, University of Colorado*

There is significant momentum around building professional learning communities for educators. However, more research is needed to understand how the design and emergent norms of such communities enable or constrain learning. We analyze how university educators with varying degrees of experience teaching with the Next Generation Physical Science and Everyday Thinking (Next Gen PET) curriculum enact conversational routines in professional development contexts that enable opportunities to learn [1]. Through analysis of community members' instructional dilemmas working with energy representations, we illustrate how the shared disciplinary and curricular context allows for collective interpretation to occur [2,3]. We argue that these conversations deepen educators' understanding of student learning in ways that likely have longer-term consequences for their pedagogical content knowledge.

[1] Work supported by NSF Grant 1626496 [2] Horn, Garner, Kane, & Brasel (2017). *J. Teach. Ed.*, 68(1). [3] Horn & Kane (2015). *J. Learn. Sci.*, 24(3).

#### **AA10: 10-10:10 a.m. An Emerging Framework for Understanding Instructional Development Teams**

*Contributed – Alice R. Olmstead, Western Michigan University, 1903 W Michigan Ave., Kalamazoo, MI 49008-5288; alice.olmstead@wmich.edu*

*Diana Sachmpazidi, Charles R. Henderson, Andrea L. Beach, Western Michigan University*

Change efforts involving teams are becoming increasingly popular at higher education institutions across the U.S. Such teams can create higher quality outcomes and more sustained improvements than instructors working alone. But not all team-based efforts are successful, and research in this area is limited. We are developing a framework that explains how structural and contextual factors might influence teamwork processes, which are in turn closely tied to team outcomes. In this talk, we will focus on the categories in the framework that emerged from our initial interviews with project leaders. These categories include the flexibility of team boundaries, how teams form, and the nature of rewards to team members. We will discuss how research about teams in other contexts has enhanced our understanding of what project leaders have observed locally, as well as what cannot be answered without further context-specific work. We will conclude by providing recommendations for change leaders.

#### **AA11: 10:10-10:20 a.m. Investigating Participants' Perspectives on What Leads to Instructional Team Success**

*Contributed – Diana Sachmpazidi, Western Michigan University, 1903 Western Michigan Ave., Kalamazoo, MI 49008; ntiana.sachmpazidi@wmich.edu*

*Alice Olmstead, Charles Henderson, Andrea Beach, Western Michigan University*

Team-based change efforts are a promising model for improving undergraduate STEM instruction. However, current literature on this topic is limited. To address this gap, we are investigating the characteristics of such teams. In particular, our research focuses on understanding teamwork processes, which are closely tied to team outcomes. In this talk, we present pilot data from interviews with team members. This data represents three different types of instructional teams: interdisciplinary teams, teams initiated within single departments, and teams that are part of cross-campus, multi-discipline initiatives. We will present team members' perspectives on, for example, how their team processes were established, the nature of their collaboration, and how conflicts that emerged during their work were resolved. Finally, we will discuss how team members' perspectives enhance what we learned from our initial interviews with project leaders as described in our previous talk.

#### **AA12: 10:20-10:30 a.m. Instructors Support of Students' Behavior in an Upper-Division Physics Course**

*Contributed – Dina Zohrabi Alaei, KSU, 116 Cardwell Hall 1228 N. 17th St., Manhattan, KS 66506; dindinzalaei@gmail.com*

*Eleanor C. Sayre, KSU*

Being involved in physics education we cannot avoid the important role of instructors. We studied the role of instructors in an advanced undergraduate E & M course using an answer-making and sense-making framing theory perspective. According to sense-making and answer-making framing, we focused on the students' behavior and how can instructors change the students' frame. Our data comes from video base observational-data and clinical interviews with instructors. We argue for a continuum from answer-making to sense-making in which students display behaviors of both and how instructors can use different kinds of problem statements and facilitation to encourage students to fall in different places in the continuum.

#### **Session AB: PER: Mathematical Reasoning and Problem Solving**

**Location:** Mount Vernon Square A    **Sponsor:** AAPT/PER    **Time:** 8:30–10:30 a.m.    **Date:** Monday, July 30    **President:** Daniel Smith

#### **AB01: 8:30-8:40 a.m. Some Mathematical Aspects of Physics Students' Problem-Solving Difficulties\***

*Contributed – David E. Meltzer, Arizona State University, College of Integrative Sciences and Arts, Mesa, AZ 85212; david.meltzer@asu.edu*

*Dakota H. King, Arizona State University*

Over the past three years, we have examined mathematical difficulties encountered by students in introductory physics courses and have documented a variety of issues with trigonometry, vector representation, and algebraic problem-solving. Here we wish to place our findings in the context of previous work by other investigators. In particular, Torigoe and Gladding [Am. J. Phys. 79, 133 (2011)] revealed significant and striking differences in correct-response rates on problems in introductory physics courses, depending on whether the problems were posed in numerical or "symbolic" form (i.e., with symbols replacing numerical values for mass, velocity, time, etc.). Other work in mathematics education examined specific difficulties associated with algebraic manipulations and symbolic representation [for example, Payne and Squibb (1990) and Booth et al. (2014)]. We will provide an overview of our own findings, and outline a broader framework in which findings from all of these related investigations may be reconciled with each other.

\*Supported in part by NSF DUE #1504986

#### **AB02: 8:40-8:50 a.m. Exploring Physics Students' Difficulties in Solving Symbolic Algebra Problems\***

*Contributed – Dakota H. King, Arizona State University, 1519 E Hale St., Mesa, AZ 85203-3819; dhking1@asu.edu*

*David E. Meltzer, Arizona State University*

As part of an investigation into students' mathematical difficulties in introductory university physics courses, we have administered written diagnostics which include multiple, high-school-level algebra problems in both their symbolic and numeric form. ("Symbolic" and "numeric" refer to the nature of the constant coefficients.) We find that symbolic algebra problems are significantly more difficult than numeric problems of the same form, for students in both algebra- and calculus-based courses. We are analyzing students' written work in detail, as well as carrying out one-on-one problem-solving interviews, in order to identify students' specific struggles in solving symbolic equations. In this talk we will report on our methods and most recent findings.

\*Supported in part by NSF DUE #1504986

#### **AB03: 8:50-9:00 a.m. Unique Instructional Framework for Elevating Students' Quantitative Problem Solving Abilities**

*Contributed – Edward Prather, University of Arizona and The Center for Astronomy Education, 933 N Cherry Ave., Tucson, AZ 85719; eprather@as.arizona.edu*

*Colin Wallace, The University of North Carolina at Chapel Hill*

We present an instructional framework that allowed a first time physics instructor to improve students quantitative problem solving abilities by more than a letter grade over what was achieved by students in an experienced instructor's course. This instructional framework uses a Think-Pair-Share approach to foster collaborative quantitative problem solving during the lecture portion of a large enrollment introductory calculus-based mechanics course. Through the development of carefully crafted and sequenced TPS questions, we engage students in rich discussions on key problem solving issues that we typically only hear about when a student comes for help during office hours. Current work in the sophomore E&M course illustrates that this framework is generalizable to classes beyond the introductory level and for topics beyond mechanics.

#### **AB04: 9-9:10 a.m. Impact of Mathematical Format on Physics Problem Strategy Selection**

*Contributed – Eugene T. Torigoe, Thiel College, 75 College Ave., Greenville, PA 16125; etorigoe@thiel.edu*

*Andrew Meyertholen, University of Toronto*

We studied the mathematical strategies used by students ( $N = 477$ ) to solve free response questions during a final exam. On one version of the final students saw a symbolic problem with no numbers, and then a different problem with numbers provided. On the other version of the final students saw analogous problems but with the mathematical format reversed. We coded the students' written work to see what equations the students used, and what quantities they isolated in their solutions. We found that there were many more strategies used in the symbolic problems, then in the numeric problems. We hypothesize that when students work on the numeric version, they are not guided by strategy, but by a mathematical structure, we call the Single Unknown Numeric (SUN) equation. Without that structure in the symbolic version without numbers, they are much more likely to choose a random variable to isolate and solve.

**AB05: 9:10-9:20 a.m. Students' Understanding of Algebraic Signs: An Underestimated Learning Challenge?**

Contributed – Moa Eriksson, Uppsala University, Portalgatan 89, Uppsala, 75418 Sweden moa.eriksson@physics.uu.se

Cedric Linder, Uppsala University

Urban Eriksson, Lund University

When starting to learn about vector quantities in introductory physics, it is important that students accurately understand the intended meaning of plus and minus algebraic signs in order to appropriately solve physics problems. We present a case study of 82 introductory-level physics students from Sweden and South Africa and show that the lack of understanding of algebraic signs can result in learning challenges even in the introductory topic of one dimensional kinematics. Results of this study will be described and implications for teaching will be discussed.

**AB06: 9:20-9:30 a.m. Blending Physical Directionality and Mathematical Signs**

Contributed – Tra Huynh, Kansas State University, 116 Cardwell Hall, 1228 N. 17th St., Manhattan, KS 66506; trahuynh@ksu.edu

Eleanor C. Sayre, Kansas State University

Expressing physics concepts and ideas in mathematical models is an important but challenging stage in the problem-solving process. Particularly in algebraic symbolization, understanding the meaning of signs and manipulating them sometimes turn out to be effort-demanding tasks, especially when more than two components in the mathematical expression could carry negative and positive signs. Our observational data from oral exams of students enrolled in upper-division electromagnetism I indicate their common struggles with the signs in an introductory-level problem. We use conceptual blending theory to construct different meanings that could associate with the signs and to investigate how students attribute these emergent meanings to signs and articulate all the signs in their algebraic expression. We argue that the difficulties the students encounter are not because of the lack of prerequisite knowledge but rather the complexity of choosing appropriate meanings for multiple signs. The results shed light on students' algebraic thinking and competence.

**AB07: 9:30-9:40 a.m. Examining Student Responses on Vector Addition Questions with Module Analysis**

Contributed – John B. Buncher, North Dakota State University, Department of Physics, PO Box 6050, Fargo, ND 58102; john.buncher@ndsu.edu

Emily Frederick, University of North Florida

Vector manipulation is an essential skill in introductory physics courses with which students often struggle. Difficulties with vector addition and subtraction in the arrow representation have been extensively reported. Using data collected from a first semester algebra-based introductory mechanics class we analyzed students' incorrect responses on a vector assessment involving 1D and 2D vector addition and subtraction. All vectors were represented in an arrows-on-a-grid format. We used a type of network analysis, Module Analysis for Multiple Choice Responses (MAMCR), to determine if groups of students consistently chose specific types of incorrect responses. Results and instructional implications will be discussed.

**AB08: 9:40-9:50 a.m. Exploring Student Reasoning Behind "Pattern-Matched" Position Vectors**

Contributed – Brian D. Farlow, North Dakota State University, 218 South Engineering, 1211 Albrecht Blvd., Fargo, ND 58108; brian.farlow@ndsu.edu

Marlene Vega, California State University - Fullerton

Alden Bradley, Oregon State University

Michael Loverude, California State University - Fullerton

Warren M. Christensen, North Dakota State University

While literature on the math-physics interface is plentiful, there is relatively little PER literature about student thinking on position vectors in non-Cartesian coordinate systems. One of the few works was a 2010 PERC paper by Hinrichs. Hinrichs reported that upwards of 66% of upper-division undergraduate and graduate physics students will "pattern-match" position vectors in spherical coordinates to look like those in Cartesian coordinates, i.e., many will write spherical position vectors in a form resembling  $\vec{r} = r\hat{r} + \phi\hat{\phi} + \theta\hat{\theta}$ , a Cartesian-like form. We were able to replicate similar responses through individual think-aloud interviews and further probe student thinking to gain insight as to what resources students may be activating – or not activating – while constructing algebraic expressions for non-Cartesian position vectors. We report on some of the cognitive resources and associated resource activation patterns identified in those interviews. The presented findings will inform future curriculum development in this domain.

**AB09: 9:50-10 a.m. Evolution of the Vector Concept in a Math Methods Course\***

Contributed – Michael E. Loverude, California State University Fullerton, Dept of Physics MH 611, Fullerton, CA 92834; mloverude@fullerton.edu

The vector concept broadens over the course of physics courses. In introductory courses, vectors are generally considered in terms of magnitude and direction of quantities in one-, two- or three-dimensional spaces. As students progress through a physics degree, the vector concept grows to include more abstract entities. We seek to investigate the extent to which students consider various mathematical entities as vectors and how that changes within a single course in mathematical methods. Data from several semesters of early- and post-course responses to written questions will be presented.

\*Supported in part by NSF grant PHY#1406035

**AB10: 10-10:10 a.m. Student Interpretation of Coefficients in Fourier Series\***

Contributed – Mikayla N. Mays, California State University, Fullerton, 800 N State College Blvd., Fullerton, CA 92831; mikayla89@csu.fullerton.edu

Michael Loverude, California State University, Fullerton

As part of ongoing research in student use of math in upper-division physics, we examine student understanding of Fourier analysis. Fourier series are used in a variety of physics contexts and provide the first example of non-Euclidian vector spaces for many students. This study extends previous work in which we highlighted the procedural and conceptual difficulties students have when thinking about Fourier series. We probe how students think about the constant coefficient in front of the Fourier series representation of a function and what it means when graphing the series. We also investigate whether students use the odd or even properties of a function to eliminate terms in the Fourier series. Data were collected at a large four-year university, including nine years of written data from an intermediate-level Mathematical Physics course as well as several interviews.

\*Supported in part by NSF grant PHY#1406035.

**AB11: 10:10-10:20 a.m. Student Conceptions of the Infinitesimal When Solving Electric Field Questions**

*Contributed – Gregory Mulder, Oregon State University, 6500 Pacific Blvd. SW, Albany, OR 97321; mulderg@linnbenton.edu*

Mathematics education research has shown that most students who have completed a year of calculus continue to have a weak understanding of several fundamental concepts underlying integration. These mathematical reasoning issues impact learning in introductory calculus-based physics. For example, when considering distributions of mass or charge, students must often integrate contributions from small chunks of mass or charge – symbolically this means that infinitesimals such as  $dm$  or  $dq$  need to be changed to  $dx$ . In order to better understand how students address the intersection of physics concepts with their mathematical reasoning, I asked 39 physics majors to find the electric field of a bar of charge. From this I identified several categories of coordinate system reasoning that students employed when dealing with the infinitesimal of integration. I will present some of these results along with some of what mathematics education research can tell us about student understandings of the infinitesimal.

**AB12: 10:20-10:30 a.m. Visualizing Multivariable Functions with 3D Plastic Surfaces**

*Contributed – Jonathan W. Alfson, Oregon State University, Department of Physics, 301 Weniger Hall, Corvallis, OR 97331-6507; alfsonj@oregonstate.edu*

*Paul J. Emigh and Elizabeth Gire, Oregon State University Department of Physics*

*Aaron Wangberg, Winona State University*

*Robyn Wangberg, St. Mary's University of Minnesota*

Many upper-division physics students have difficulty visualizing and representing functions of more than one variable. While traditional representations in multivariable calculus are useful for students, there is a demand for additional tools and activities to help students make connections between variables and understand the relationships among those variables. The Raising Physics to the Surface project is developing 3D plastic models (surfaces) of functions found in physical systems, such as those in electrostatics and thermodynamics. We will discuss how the surfaces are implemented in classroom instruction, how the students engage with those surfaces, and what benefits or disadvantages are provided by the inclusion of surfaces during instruction.

**Session AC: Effective Practices in Educational Technology**

**Location:** Mount Vernon Square B **Sponsor:** Committee on Educational Technologies **Time:** 8:30–10:30 a.m. **Date:** Monday, July 30 **President:** Josh Samani

**AC01: 8:30-8:40 a.m. 3D-Printing Apparatus**

*Contributed – Martin Richard Hopf, Univ of Vienna, Austria, Porzellangasse 4, Vienna, 1220 Austria martin.hopf@univie.ac.at*

3D-Printing has developed rapidly in the past few years. In Austria, most high schools already possess a 3D-printer or plan to purchase one soon. We worked with pre-service physics teachers to explore possibilities for printing physics apparatus. We began by reviewing ideas that we found online, e.g. to print a magnetic field probe or an air puck. The pre-service teachers then developed their own ideas and worked hard to design, try out, and redesign their own apparatus. Finally they came up with working designs for printing carts, a launcher, and a hydrostatic apparatus. I will present these ideas in this talk.

**AC02: 8:40-8:50 a.m. Effective Coding in Introductory Physics and Electronics**

*Contributed – Joshua Gates, The Tatnall School, 5 e Brookland Ave., Wilmington, DE 19805; joshgates@tatnall.org*

Despite the importance of coding and simulation in the real work of many physicists, introductory courses -- especially in high schools -- often omit these skills altogether. A brief overview of two paradigms (guided and project-based) for inclusion of two different programming languages (VPython/Glowscript and Arduino) in these courses will be presented. Demonstrated approaches work with novice coders and do not require extensive prior programming experience from teachers. Links to example projects and student work will be provided.

**AC03: 8:50-9 a.m. Using Pear Deck Software to Promote Student Engagement**

*Contributed – Emily James, Brewster Academy, 80 Academy Drive, Wolfeboro, NH 03894; emily\_james@brewsteracademy.org*

Academic engagement can be defined as the active involvement, commitment, and attention aimed at academic tasks. When students are engaged, studies have correlated these behaviors with increased academic success. Given the myriad of stimuli that students encounter during their daily lives (smart phones, computers, etc), engagement can become a challenge for most adolescents. Pear Deck is a web-based presentation software solution for this problem. Each student connects to the teacher's presentation on any device, answers interactive questions, and learns from their peers. The Pear Deck offers teachers the potential to harness their student's devices for good. The talk highlights the utility of the Pear Deck for engaging every student in problem solving and lab discussion/conclusions. The experience of one teacher in using this interactive software to improve the engagement of students in presentations is described.

**AC04: 9-9:10 a.m. Getting Unprepared Students Prepared**

*Contributed – Gen Long, St John's University, 8000 Utopia Pkwy., Jamaica, NY 11439; longg@stjohns.edu*

In this presentation, we report an ongoing exploring study of adopting effective practices such as just-in-time-teaching and peer-mentoring in a classroom with heavy traditional setting while adopting modern technologies (slides, videotaping lectures, poll-everywhere, etc.) to help students learn whenever they see fit. By requiring student to preview and review lectures content on their own, taking in-class quizzes, as well as providing lecture videos online, we found that the average grades of the class are improved. The pre and post assessments on physics prerequisite are also found to show improvement.

**AC05: 9:10-9:20 a.m. Prelab Video Assignments to Enhance Student Learning and Preparedness**

*Contributed – Jonathan E. Williams, Cuyahoga Community College, 31001 Clemens Road, Westlake, OH 44145; jonathan.williams@tri-c.edu*

Sensors and data collection software have become a mainstay of introductory physics laboratories. A drawback to using technology in the lab is the time required for students to become familiar with the experiments and proper use of lab software and sensors. During this time, students may become frustrated and overwhelmed with making basic measurements. In addition, students typically come to lab unprepared and oftentimes find it difficult to make a connection between lab activities and concepts covered in lectures. By creating short videos as prelab assignments, students are better prepared for labs and are less likely to make as many experimen-

tal errors during lab time, thus improving effectiveness. The assessment questions in the pre-lab assignment steers students into connecting lecture content to the lab activity being investigated. Preliminary result of students' satisfaction and learning with the implementation of the prelab assignments will be reported.

#### **AC06: 9:20-9:30 a.m. Creating Labs for Online IPLS Courses Using IOLab**

*Contributed – Christopher K. Ertl, University of Massachusetts Amherst, 666 N Pleasant St., Amherst, MA 01003-0001; certl@umass.edu*

As the demand for online courses continues to grow, we find ourselves faced with the challenging task of creating hands on labs that students can perform without having to attend in person. The IOLab hardware can be combined with simple materials to permit a wide range of laboratory experiments at a low cost. Lab activities presented include ideas for torque, buoyancy, electric and magnetic fields, and electromagnetic induction. I will also share the successful results of creating and improving these labs over the last two years which include effectiveness and student satisfaction.

#### **AC07: 9:30-9:40 a.m. Web-based Simulations as Laboratory Activities for Online Physics Classes**

*Contributed – Anthony R. Smith, Central Washington University, 400 E. University Way, MS 7422, Ellensburg, WA 98926-7501; spacetime82@gmail.com*

Laboratory activities have long been an integral part of physics education. With the increasing demand for online physics classes at the two-year college and university level, the question of how to replicate this hands-on lab component outside the classroom is of paramount importance. Full-length, college-level laboratory activities were written for Physics Education Technology (PhET) simulations, filling much of the role of hands-on experiments in a traditional classroom. These labs guide students through the process of collecting and analyzing data, answering conceptual questions about the Physics which is simulated, and summarizing and explaining their results. The topics cover a variety of material throughout the Introductory (Algebra-based) Physics sequence, such as friction, Hooke's law, and capacitors, rounding out the involvement of students in a high-context online environment.

#### **AC08: 9:40-9:50 a.m. Complete Introductory Physics Courses Online**

*Contributed – David Pritchard, MIT, Room 26-241, Cambridge, MA 02139-4307; dpritch@mit.edu*

*Byron Drury, MIT*

*Zhongzhou Chen, Univ Central Florida*

*Isaac Chuang*

Evidence suggests that blending online and on-land teaching in some sort of flipped classroom results in more learning than either extreme. Unfortunately, optimally combining online, in-class, weekly homework and quizzes, and on-paper activities presents a formidable and time-consuming organizational challenge for the instructor. We are assembling sets of these resources into complete courses for intro mechanics and E&M at both algebra- and calculus-based levels. These can be flexibly assigned in the open-source online platform -- edX.org. Importantly, student interaction data are recorded in BigQuery; we extract problem difficulty and time on each resource, and can improve the course through research. These courses will be available as Customizable Courses this fall, and possibly in Canvas. Ultimately we will use the Harvard DART system to allow teachers to assemble courses from a library with descriptive and performance metadata about each resource. Volunteers are solicited for beta-testing and for curating existing resources.

#### **AC09: 9:50-10:00 a.m. Physics Mastery Modules: An Open First-Year Physics Learning System**

*Contributed – Joseph D. MacMillan, University of Ontario Institute of Technology, 2000 Simcoe Street North, Oshawa, ON L1H 7K4, Canada; joseph.macmillan@uoit.ca*

*Rupinder Brar, University of Ontario Institute of Technology*

In many introductory university courses, including physics, online homework systems have mostly replaced traditional hand-written assignments; however, the most common online systems are provided by textbook publishers, which can be expensive and inflexible. Using the results of education research, we identified a "mastery setting" as a good model for homework delivery. In an effort to improve effectiveness and eliminate cost of online homework assignments at the first-year level of all physics courses at the University of Ontario Institute of Technology (UOIT), we built an online open-education learning system entitled Physics Mastery Modules. In this presentation we will describe this initiative, as well as quantify the statistically significant improvements in student performance and engagement.

#### **AC10: 10:00-10:10 a.m. Moodle Quiz Formatted OER Learning Modules**

*Contributed – Robert E. Greeney, Holyoke Community College, 76 McClellan St., Amherst, MA 01002; rgreeney@hcc.edu*

I have developed a wide variety of physics learning and assessment exercises to be shared, used, and enhanced over time through peer collaboration among physics instructors. These exercises are authored in the format of Moodle Quizzes. The exercises are easily shared with anyone who has access to Moodle Learning Management System (LMS). Motivation for this initiative includes: a. Enhanced learning of physics, b. Convenient and effective assessment vehicles that promote learning, c. Easily shared and used OER learning and assessment exercises, d. Promote creative and productive collaboration among physics instructors, e. Quality cost saving options for faculty and students, f. Contribute to the growth and improvement of OER in physics

#### **AC11: 10:10-10:20 a.m. A Non-Traditional Database that Is Much More Time-Efficient in Improving Teaching Effectiveness**

*Contributed – Rolex Rao, Future Start, 1570 Tenaka Place, #1, Sunnyvale, CA 94087; futurestartclass@gmail.com*

As we all know, test assessment is very essential in determining the teaching effectiveness. Often times, it's unsafe for a teacher to use the same paper that was tested last semester, but it's very time consuming for a teacher to write a set of new questions for a specific test every semester, so a database that allows a teacher to save their time in preparing the test becomes very meaningful. We find an effective way for teachers to make their new test quickly; they can save 90-99% of their time in test-preparation. Teachers don't have to know any computer languages or understand any of the traditional database, such as access, oracle, etc.; they can store, sort, and reuse the test questions without worrying about portability. This technology is also very useful in online teaching.

#### **AC12: 10:20-10:30 a.m. Video Analysis in Introductory Physics Courses**

*Contributed – Imad A. ElJeaid, Middle Georgia State University, 1100 second Street S.E, Cochran, GA 31014; imad.eljeaid@mga.edu*

The use of "Video Analysis" as a supplementary course activity can help solidify and further students' knowledge of crucial concepts and ideas portrayed in the classroom. Video Analysis requires the use of very accurate and hi-tech instrumentation, such as the "Casio EX-F1" camera, used for record high definition and high-speed video. In other cases where this technology is unavailable, the instructor may provide an already existing video, along with the written document required, to the students for data collection and analysis. Thereafter, the video will be uploaded onto the "Tracker" software or the "LoggerPro" for further analysis in two dimensions. The Data collected by the students, typically in Groups of 4, will be used to analyze and calculate given parameters, using graphical analysis methods, along

with the laws of physics. In general, students can improve their understanding of a surprisingly broad range of topics including Newtonian mechanics, Mechanical and Sound waves propagation, Classical Thermodynamics, Optics, Electricity and Magnetism. These live photo video activities give students the experience of working together in groups to apply the laws of physics to world phenomena that simply cannot be obtained by listening to lectures, reading texts, and/or by solving problems. Students through these activities will be able to: 1) To examine the movie frames 2) To make predictions 3) To collect video data, correlate video and sensor data 4) To replay movies as graphs of previous video/sensor data points appear 5) To derive equations, fit curves, and do analytical mathematical modeling

## Session AD: High School

Location: Marriot Marquis - Magnolia Sponsor: AAPT Time: 8:30–10:30 a.m. Date: Monday, July 30 President: Deborah Roudebush

### AD01: 8:30-8:40 a.m. Introduction and Strategies for New Styles of AP Physics Questions

Contributed – Matthew H. Skalor, 16 Unity Court, Nesconset, NY 11767; [apphysics@verizon.net](mailto:apphysics@verizon.net)

The revised AP Physics 1 and AP Physics 2 courses have introduced two new styles of questions that students will see every year. Their design is based on the scholarship of teaching and learning from the Physics Education Research community. The “Qualitative Quantitative Translation” question, which assesses aspects of mathematization, and the “Experimental Design” question require students to demonstrate their physics knowledge and skills in specific and novel ways. In this talk, the audience will be introduced to these new question styles using recently released exam questions and rubrics. Matthew Skalor will share this information from the vantage point of a question and rubric writer, a veteran AP physics teacher and a long time AP exam reader and leader. Also discussed will be strategies for teachers to effectively prepare their students to be able to answer these question types.

### AD02: 8:40-8:50 a.m. The Making of an AP Rubric

Contributed – Matthew Ted Vonk, University of Wisconsin River Falls, 410 S 3rd St., River Falls, WI 54022; [matthew.vonk@uwrf.edu](mailto:matthew.vonk@uwrf.edu)

Have you ever wondered how Advanced Placement (AP) tests are scored? Why do some parts of a student response earn credit while others don't? ...And are there clues in the way that a question is worded that indicate something about how it might be scored? The key to understanding how AP tests are scored is the rubric. In this session, the audience will get an inside view as to how a rubric gets made and applied. Matt Vonk is a member of the AP Physics C development committee and a longtime AP reader.

### AD03: 8:50-9 a.m. Applying Rubrics at the AP Physics Reading

Contributed – Oather B. Strawderman, Lawrence Free State High School, 524 Boulder St., Lawrence, KS 66049; [ostrawde@usd497.org](mailto:ostrawde@usd497.org)

Great care is taken at the AP Reading to ensure that the reported scores are both fair and reliable. One of the ways we make sure this occurs is through the use of carefully constructed and applied rubrics. In this session we will see how rubrics are utilized at the AP Reading to score exams. We will discuss how the rubric is finalized at the Reading after a thorough review of student samples to ensure that all answers that address the Learning Objectives receive credit. The importance of uniformly applying the rubric and how this is achieved through Reader training and back reading will also be addressed. Throughout the presentation actual rubrics for released exam questions as well as student samples will be referenced. Oather Strawderman is a member of the AP Physics 2 Test Development Committee and a Question Leader at the AP Reading.

### AD04: 9:00-9:10 a.m. Project Accelerate: Blended SPOC Bringing AP Physics to Underserved Students\*

Contributed – Andrew G. Duffy, Boston University, Department of Physics, Boston, MA 02215; [aduffy@bu.edu](mailto:aduffy@bu.edu)

Mark D. Greenman, Boston University

Boston University is in the first year of implementing a three-year NSF DRK12 award bringing AP Physics to underserved populations. During our prior pilot year, Project Accelerate partnered with 11 high schools in Massachusetts and West Virginia to bring a College Board approved Advanced Placement® Physics 1 Small Private Online Course (SPOC) to schools not offering this opportunity to students. Project Accelerate students (1) outperformed peer groups in traditional AP Physics classrooms on the College Board AP Physics exam, and (2) were more inclined to engage in additional Science, Technology, Engineering and Mathematics (STEM) programs than they were prior to participating in Project Accelerate. Project Accelerate combines supportive infrastructures from a student's traditional school, a highly interactive private edX online course, and small group laboratory experiences. Project Accelerate offers a replicable solution to a significant problem -- too few underserved high school students having access to high quality physics education, resulting in these students being ill prepared to enter STEM careers and STEM programs in college.

\*Funded by NSF grant DRL 1720914.

### AD05: 9:10-9:20 a.m. AP Physics 1: A Seasoned Perspective

Contributed – Brian Holton, Mt. Olive High School, 36 Smith St., Blirstown, NJ 07825; [bholton@mtoliveboe.org](mailto:bholton@mtoliveboe.org)

The evolution of AP Physics B into AP Physics 1 and 2 has significantly changed how high school physics takes place in America's schools. AP Physics 1/2 has moved away from being equivalent to most algebra-based college physics courses in that its emphasis is on process rather than content. While enrollment has increased from 93,500 in the 2014 AP B course to 174,000 in the 2015 AP 1 course, only 18.6% of students taking the AP 1 test scored a 4 or 5 compared to AP B's 32.8% these years. In addition, while AP Physics B was a comprehensive course covering the college equivalent of a first year course, AP Physics 1 and 2 is a two year sequence. Only 26,400 students took AP Physics 2 in 2015 realizing a loss of 67,000 students not being exposed to second semester topics. This talk will compare and contrast the Physics B and Physics 1/2 from the perspective of a 35-year seasoned high school teacher and college professor.

### AD06: 9:20-9:30 a.m. Computational Modeling in High School Physics

Contributed – William H. Fenton, The Hotchkiss School, 11 Interlaken Road, Lakeville, CT 06039-2130; [billyfenton@gmail.com](mailto:billyfenton@gmail.com)

Jesse Young, Baylor School

We will present the way we integrate computational models with the Modeling Instruction(1) curriculum we use to teach AP Physics 1. When students are shown a situation with a changing net force or mass they find that their standard algebraic and graphical toolkit is not sufficient to make a model that can be used to make

quantitative predictions. By introducing VPython early in the course, students eventually regard it as “just another tool” and, realizing that the force or mass don’t change “too much” if the time interval is short enough, successfully use Euler’s Method to model air resistance, oscillatory motion, planetary motion, and rocket propulsion without any knowledge of calculus. We will show how we introduce computational tools in our curriculum, how students make use of them and show some examples of student work.

(1) [www.modelinginstruction.org](http://www.modelinginstruction.org)

#### **AD07: 9:30-9:40 a.m. A Family of Arduino-based Instruments for Linear and Rotational Kinematics**

*Contributed – Sidharta MJ Vadaparty, Montgomery High School, Skillman, NJ08502, 85 Millers Grove Road, Belle Mead, NJ 08502-4300; shvadaparty@yahoo.com*

Kinematics in linear and rotating motion is core to introductory physics and should be internalized by high school students through hands-on experiments. However, subtle concepts like non-inertial frames and Coriolis force are often taught qualitatively. Additionally, commercially available instruments which can quantitatively measure these phenomena are often prohibitively expensive. In this presentation, we will introduce two instruments, Kinemeter and Cirkinemeter, which measure velocity and acceleration on a straight line and on a rotating disk, respectively. These classroom-tested instruments are built using Arduino microcontrollers, and are affordable, customizable and open-sourced. Through the data collected from a number of creative experiments using these instruments, we deduce the familiar kinematics equations in linear and circular motion to a high degree of precision. We also show how to measure  $g$ ! The Cirkinemeter helps to clear students’ confusion in centrifugal acceleration (fictitious vs. real), and also demonstrates Coriolis force quantitatively.

1. A. Steyn-Ross and D.G. Ivey, “Frames of Reference Revisited”, American Journal of Physics. 60 1069-1085 (December 1992). 2. Sanjay Sarma, “Rotating Frames of Reference”, MIT Open-courseware, <https://www.youtube.com/watch?v=IOcrHOc23N4>, Published Jan 2014, MIT.

#### **AD08: 9:40-9:50 a.m. Use of 3D Pens in High School Physics Labs**

*Contributed – Anne Huntress, South Lewis Central School, 6822 McAlpine, Lyons Falls, NY 13368; anne.huntress@yahoo.com*

Learn how to have students design, construct, and engineer using 3D pen technology. No coding is necessary, just an outlet and an imagination! Participants will be introduced to how I use these pens in my Regents Physics classes to make bridges, amusement park rides, and windmills, but will also have ample time to play and brainstorm how to implement this technology into their own classrooms.

#### **AD09: 9:50-10:00 a.m. Teaching Thermodynamics in a Unique High School Environment**

*Contributed – Boaz Karni-Harel, HEMDA, Hapardes St., 7, Tel Aviv, Israel 6424534 Israel boazk@hemda.org.il*

HEMDA–Schwartz-Reisman Science Education center in Tel-Aviv is a unique educational institute. It is a non-profit organization that provides science education to all the high schools in Tel-Aviv. This enables it to provide excellent laboratory equipment and highly trained teachers, most of them PhD holders. Taking advantage of this, the center offers the students many activities and classes beyond the regular curriculum. As an example a new course in thermodynamics will be presented. The difficulties and the ways they were overcome will be discussed.

#### **AD10: 10:00-10:10 a.m. Teaching Quantum Mechanics in High School**

*Contributed – Efraim Yehuda Weissman, The Hebrew University of Jerusalem, Israel, Shirat Haleviyim 3, Mitzpe Yericho, Israel 9065100 Israel efy.wei@gmail.com*

*Avi Merzel, Nadav Katz, Igal Galili, The Hebrew University of Jerusalem, Israel*

The currently adopted high-school curriculum of modern physics is often extremely short including a few initial steps towards quantum theory. The wave-particle duality is mentioned, but often without the meaning of waviness of particles. The contrast between the classic and quantum theories often misses any discussion. Our new curriculum adopts the paradigm of discipline-culture in representing physical knowledge. Within this paradigm, a physical theory is structured around a nucleus-body-periphery which emphasizes the principles (nucleus), their application (body) and alternatives (periphery). An experimental curriculum was developed and applied. The first results show a positive impact on students’ conceptual knowledge.

#### **AD11: 10:10-10:20 a.m. Astrophysics High School Internship Program: Hands-On Research Experience**

*Contributed – Ellie Feitlinger, University of Wisconsin-Madison, 222 W Washington Ave Suite 500, Madison, WI 53703-2775; ellie.feitlinger@icecube.wisc.edu*

*Silvia Bravo, Jean DeMerit, University of Wisconsin-Madison*

In 2013, the Wisconsin IceCube Particle Astrophysics Center (WIPAC) launched a summer and fall high school internship program. The summer internship invites 4-5 students and one teacher to work full time on a six-week-long research project. The fall internship invites 10-20 students to join WIPAC two hours per week for up to 12 weeks. Both internships offer innovative and genuine astrophysics research experiences for the students. We challenge interns to apply methods of scientific inquiry and analyze data contributing to actual experiments. Students work in small groups with a lead scientist on each project. At the end of the internship, and weekly during the summer, students present their work and answer questions from researchers and peers. We will discuss the challenges and opportunities of the high school program, including how teachers can engage with and benefit from this program.

Kenneth W. Cecire, Chair, Committee on Modern Physics

#### **AD12: 10:20-10:30 a.m. An Agency by Design Framework for Physics Labs and Lessons**

*Contributed – Stephen March, Washington International School, 3100 Macomb St. NW, Washington, DC 20008; steve.march@wis.edu*

Agency by Design (AbD) is a research initiative to investigate the promises, practices, and pedagogies of maker-centered learning. At Washington International School, we have been working with Project Zero researchers to implement AbD across the curriculum. This talk introduces the fundamentals of the Agency by Design framework in the context of High School physics and provides examples of ways one teacher has implemented the framework in his classes.

## Session AE: Inclusivity and Diversity in STEM

Location: Marriott Marquis - Cherry Blossom Sponsor: Committee on Women in Physics Time: 8:30–10:30 a.m. Date: Monday, July 30 President: Scott Franklin

### AE01: 8:30-9:00 a.m. Diversity and Inclusion in STEM: Figuring It Out Together

Invited – Shirley M. Malcom, AAAS, 1200 New York Ave., NW, Washington, DC 20005; smalcom@aaas.org

Despite years of interventions there has been only modest improvement in participation levels in physics by women and underrepresented minorities. Diversity and inclusion are important but unrealized goals of the physics community, including the physics education community. What can be learned from other fields that can support physics' goals of diversity and inclusion? Can progress be achieved by making links between physics and other areas of science, that is, exploring interdisciplinary topics or focusing on important global problems? The STEM DBER Alliance was convened to look at possible benefits and lessons learned while supporting collaboration across discipline based education research communities as we tackle large, intractable challenges such as diversity and inclusion.

### AE02: 9:00-9:30 a.m. Research on Diversity Initiatives in Computing

Invited – Burcin Tamer, Computing Research Association (CRA), 1828 L St NW Ste. 800, Washington, DC 20036; burcin@cra.org

Diverse perspectives foster innovation and ensure the needs of many are met. At present, computing fields lack demographic diversity. This presentation will focus on factors that often encourage (or discourage) women as well as men from underrepresented racial groups from engaging in computing degrees. In particular, the audience will learn about recent research conducted at the Computing Research Association's Center for Evaluating the Research Pipeline (CERP). CERP conducts national survey research to understand explanations for low diversity in computing education. CERP also studies the efficacy of intervention programs aiming to build diversity in computing. The audience will be given actionable items, rooted in research, to help foster diversity in STEM education.

### AE03: 9:30-10:00 a.m. Detailing STEM Educational Opportunities that Affirm Marginalized Students' Intersectional Identities

Invited – Luis A. Leyva, Vanderbilt University - Peabody College of Education & Human Development, PMB 230, GPC, 230 Appleton Place, Nashville, TN 37203-5721; luis.a.leyva@vanderbilt.edu

Black and Latinx populations are significantly underrepresented in STEM, earning less than 10% of mathematics-intensive degrees (e.g., engineering, physics) in 2014. With mathematics operating as a gatekeeper of advanced STEM coursework, qualitative analyses of social influences on historically marginalized populations' mathematics success can illuminate ways to advance STEM retention and inclusion. Drawing on research that looks across observations and student journaling in undergraduate mathematics classrooms as well as student reflections, this presentation details how STEM student support services, faculty relationships, and teaching shaped inclusive mathematics educational experiences among students of color. I use intersectionality -- a theoretical perspective that captures the interplay of racism, sexism, and other systems of oppression in shaping unique forms of marginalization -- to illustrate variation in how students of color negotiate their social identities with STEM pursuits. Implications are raised to inform postsecondary STEM educational programs and practices that are socially affirming of marginalized intersectional identities.

### AE04: 10:00-10:30 a.m. Exploring the Influence of Covert Identities in Active Learning Classrooms

Invited – Sara E. Brownell, Arizona State University, 407 E Tyler Mall, Tempe, AZ 85281; sara.brownell@asu.edu

As we transition our college biology classrooms from traditional lectures to student-centered active learning, the dynamics among students become more important. These dynamics can be influenced by student social identities. We are interested in hidden or covert identities that are stigmatized, so that students may feel uncomfortable sharing their identity in the classroom. We have explored two stigmatized covert student identities that have thus far been unexamined in undergraduate biology classrooms: lesbian, gay, bisexual, transgender, queer, intersex, and asexual (LGBTQIA) identities and students who have anxiety. Using semi-structured interviews, we probed the perceptions of 7 LGBTQIA students and 52 students with differing levels of anxiety in undergraduate biology classrooms that were being taught using active learning. We found that these students' covert identities are affecting their experiences in the classroom and that there may be specific instructional practices that can mitigate some of the possible obstacles for these students.

## Session AF: Introductory Labs/Apparatus

Location: Marriott Marquis - Dogwood Sponsor: AAPT Time: 8:30–10:30 a.m. Date: Monday, July 30 President: André Bresges

### AF01: 8:30-8:40 a.m. Transformation of Experimental Physics 1 at CU Boulder\*

Contributed – Daniel R. Bolton, University of Colorado Boulder, 2000 Colorado Ave., Boulder, CO 80309; daniel.bolton@colorado.edu

By multiple measures, the introductory "Experimental Physics" course at CU Boulder was not meeting expectations and the department sought a re-design. We will discuss the multi-year process of this re-design (the new course was taught for the first time in spring '18). Although some specifics of the new course will be presented, emphasis will be on the process of the re-design. A series of interviews, surveys, and round table discussions produced learning goals, many of which required a different approach than the traditional introductory lab. The learning goals influenced course structure and activity choices. We will transit lessons learned about course transformation in general, and discuss the successes of failures of the new course.

\*This work was supported in part by the TRESTLE program with funding from the NSF (DUE 1525331).

### AF02: 8:40-8:50 a.m. Results from Piloting a Design-style Lab in Introductory Algebra-based Mechanics

Contributed – William R. Evans, University of Illinois at Urbana-Champaign, 1110 West Green St., Urbana, IL 61821; wevans2@illinois.edu

Mats A. Selen, University of Illinois at Urbana-Champaign

At the University of Illinois, we have piloted a new design-style laboratory that focuses on sense-making and the acquisition of scientific skills in our algebra-based introductory mechanics course, which primarily serves life science students. This lab format was piloted for two semesters in 2017 with part of the class (2-3 sections) in preparation for scaling it up to the entire class. We collected data on both students' attitudes and conceptual learning using traditional instruments. We compare these data from students in the reformed laboratory sections with data from students in the more traditional step-by-step guided labs.



### AF03: 8:50-9:00 a.m. What's Happening in Traditional and Inquiry-based Introductory Labs? An Integrative Analysis at a Large Research University

Contributed – Danny Doucette, University of Pittsburgh, 504 Coal St., Apt. 3, Pittsburgh, PA 15221-3588; danny.doucette@gmail.com

Russell Clark, Chandralekha Singh, University of Pittsburgh

Introductory lab courses have long been an essential component of physics instruction, but questions have been raised about their curricular role and value. As a first step toward reform, it is essential to understand the dynamics of what happens in the lab. Using an integrative approach that includes ethnography, surveys, assessments, and other tools, we mapped out the thinking, instruction, and social dynamics that take place in traditional and inquiry-based labs at a large public university. Findings will be discussed. We thank the National Science Foundation for support.

### AF04: 9:00-9:10 a.m. Recharging the Introductory Labs: Evaluating Concepts and Techniques

Contributed – Dimitris Vassiliadis, Washington and Jefferson College, 60 S. Lincoln St., Department of Physics, Washington, PA 15301-4801; d\_vassi@yahoo.com

Undergraduate labs are a constant challenge in curriculum design with goals ranging from pedagogy to lecture-course scope to PER and budgets. Having recently taught a handful of introductory labs, I'd like to discuss some topics that seem relevant to PER findings. First is a type of iterative experimentation where students build versions of the experiment in a lab session while measuring uncertainty and error. The focus shifts from error reduction to quantifying the role of equipment and procedure on experimental accuracy, and to related issues. Second, letting students suggest changes in experiment design, and in some cases allowing them to implement their choices, appears to increase understanding/retention as well as their connection to the subject matter. Third, the above-mentioned labs were on E&M and thermal physics so I will go over some related techniques.

References: N. Holmes and C. Wieman, PT 71, 1, 2018. Acknowledgments: Thanks to AAPT and W&J for travel support to a AAPT workshop in 2017.

### AF05: 9:10-9:20 a.m. Semi-Authentic Lab Notebook Experiences using Post-Lab Exercises

Contributed – Adam C. Lark, Hamilton College, 198 College Hill Rd., Clinton, NY 13323; alark@hamilton.edu

Viva Horowitz, Jonathan Gaffney, Hamilton College

Training physics majors how to keep a useful and relevant lab notebook is a typical goal of introductory physics laboratories. However, students often view these laboratories as inauthentic experiences. With most of the information given by the lab instructions, students are less motivated to record observations in their lab notebook. To reinforce the value of recording experimental information and to help students decide which information is important, the Hamilton College physics department has decided to implement a post-lab system. We ask students to keep their own notebook and write down what they consider important. A few days after the lab, the students are given a post-lab assignment that asks them questions about the details of what they did during the lab. This has helped students organically discover what is valuable to record during their introductory physics laboratory.

### AF06: 9:20-9:30 a.m. Chi-squared Analysis and Model Testing in Harvard's Introductory Physics Lab

Contributed – Keith Zengel, Harvard University, 1 Oxford St., Cambridge, MA 02138; zengel@fas.harvard.edu

Carey Witkov, Harvard University

Some of the most spectacular discoveries of our times, e.g., the Higgs Boson and gravity waves, rely heavily on chi-squared curve fitting and model testing. Long used in the particle physics community, chi-squared analysis is computation-intensive, improving upon ordinary least squares by combining model testing and parameter estimation into one unified method derived from probability theory, maximum likelihood estimation and the central limit theorem. By emphasizing uncertainties obtained from repeated measurements and by providing a continuous gauge of model improvement, chi-squared analysis offers a consistent methodology for iterative refinement of models, the sine qua non of the scientific method. Chi-squared curve fitting and model testing has been the central theme of Harvard's introductory physics lab course (Principles of Scientific Inquiry) for over a decade. This paper presents our experience teaching chi-squared analysis and applying it to a wide range of novel mechanics and electricity and magnetism introductory physics lab projects.

### AF07: 9:30-9:40 a.m. Practical Exams: Examples and Practice from the Past 15 Years

Contributed – Stephen H. Irons, Yale University Department of Physics, 217 Prospect St., New Haven, CT 06511-8499; United States stephen.irons@yale.edu

The lab practical exam is one way to assess a student's understanding of the lab's learning goals. However, practical exams can be difficult to implement effectively and fairly, and there are complexities regarding assessment. They have long been a part of both our IPLS labs as well as our introductory labs for majors. We will present a selection of the practical exam activities we have developed that are consistent with the NGSS and also implement the AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum. Many of these exam/activities are adaptable to the K-12 environment and can be modified to be more economical. We will also discuss strategies for successful exam administration and present some analysis of recent student performance across sections.

### AF08: 9:40-9:50 a.m. Using Whiteboards to Support Scientific Practices in Introductory Labs

Contributed – Benjamin T. Spike, University of Wisconsin-Madison, Department of Physics, 1150 University Ave., Madison, WI 53706-1390; btspike@wisc.edu

As part of an ongoing course transformation effort at the University of Wisconsin-Madison, we have introduced a suite of introductory mechanics laboratories to promote experimental design and scientific thinking. Inspired by ISLE Physics and Scientific Community Labs, each two-hour lab features a set of conceptual scaffolding activities, an open-ended design challenge, and a miniature "symposium" to emphasize collaboration and communication. In lieu of a formal lab report, each group uses a whiteboard to document their experimental approach and submits a digital snapshot when they have finished. Informal tools such as stopwatches and matchbox cars contribute to a relaxed, playful atmosphere that encourages students to answer their own questions and explore at their own pace. In this talk, we will describe our initial implementation of these labs and share preliminary findings.

### AF09: 9:50-10:00 a.m. Using IOLab to Enable ISLE Style Labs at Scale

Contributed – Mats A. Selen, University of Illinois at Urbana-Champaign, Department of Physics, 1110 W. Green St., Urbana, IL 61801; mats@illinois.edu

Bill R. Evans, Gabriel S. Ehrlich, University of Illinois at Urbana-Champaign

Starting in the spring of 2018, we significantly changed the lab component for all students taking algebra-based intro mechanics at UIUC. We replaced the traditional concept-focused cookbook-style labs with open-ended ISLE style activities, enabled by the IOLab system, and focused on scientific abilities such as design, sense-making, and communication. We report on our experiences and discuss plans to make similar changes to the other introductory physics courses at UIUC, ultimately impacting about 3000 students per semester.

**AF10: 10:00-10:10 a.m. Extending the Introductory Physics Laboratory to Free Falling Objects with Drag Forces**

Contributed – Paul R. DeStefano, Portland State University, P.O. Box 751, Portland, OR 97201-0751; paul.destefano-aapt@vfemail.net

Cora Seibert, Ralf Widenhorn, Portland State University

Thomas Allen

Recently introduced, low-cost, local positioning and sensing technology have great potential for enhancing introductory kinematic laboratory activities. One of the key benefits is quick and easy acquisition of position, acceleration, and rotation data. This enables students to access some of the physics of real-world application for example the modeling of trajectories including air resistance. Students can apply both a constant acceleration and drag-enhanced model to data sets obtained from drops or throws of foam balls or the launch of compressed-air rocket. The data analysis can span a range of complexity. Students may try to model the data using simple constant acceleration or model it with velocity dependent drag forces. Since acceleration data can be collected simultaneously, results from the modeling of position data can be compared to the direct measurement of the instantaneous acceleration.

**AF11: 10:10-10:20 a.m. Bringing a Desktop MRI into Your Physics Classroom**

Contributed – Sanaz Taghizadeh, \*UCLA / Hoag Hospital, 28521 Rancho Grande, Laguna Niguel, CA 92677; sunnytaghizadeh@gmail.com

James Lincoln, SCAAPT

With many students planning to pursue a career in medicine, it is the responsibility of physics teachers to instruct on the concepts of Magnetic Resonance Imaging (MRI). In this talk I provide a brief overview of Nuclear Magnetic Resonance and discuss how nuclei interact with magnetic fields. I also share my work on a desktop MRI apparatus and demonstrate how it can be used to create MR Images during a single class period.

\*Sponsored by James Lincoln

**AF12: 10:20-10:30 a.m. Demonstrating the On-Axis Electric Field of a Charged Ring**

Contributed – William Roach, Lynchburg College, 1501 Lakeside Dr., Lynchburg, VA 24501; roach.w@lynchburg.edu

A common exercise in introductory electricity and magnetism courses is the calculation of the electric field on the axis of a ring of charge. An apparatus was developed to help students visualize this field using a pith ball. In addition to demonstrating the electric field produced by the ring, the apparatus allows students to “see” a derivative as the pith ball moves through the field. After setting up the force diagram describing the situation, students use video analysis to record the horizontal position and angular displacement of the pith ball. Because the charge of the pith ball and ring are unknown, this lab also serves as an excellent opportunity to introduce students to computational modeling using software such as Mathematica in order to extract the unknown quantities.

**Session AG: Introductory Physics for Life Science: Pedagogy and Practice** Location: Meeting Room 8/9

Sponsor: Committee on Physics in Undergraduate Education Co-Sponsor: AAPT Time: 8:30–10:30 a.m. Date: Monday, July 30 President: Nancy Beverly

**AG01: 8:30-9:00 a.m. Modeling Structure Formation in Biological Systems**

Invited – Elon Langbeim, Weizmann Institute of Science, 234 Herzl St., Rehovot, Israel 7610001; Israel.elon.langbeim@weizmann.ac.il

Samuel Safran, Edit Yerushalmi, Weizmann Institute of Science

How can Monte-Carlo simulations be used for explaining the emergence of biological mesoscale structures? We propose answers to this question based on our experience in an introductory-level computational physical science course. Students used VPython to construct and modify Monte-Carlo simulations and learn their underlying principles. The simulations demonstrate how structure arises in systems with two types of interactions: 1. Short-range depletion (excluded volume) interactions (e.g., a system of “self-avoiding” polymer chains), 2. Long-range inter-molecular attraction (e.g., the adsorption of molecules to a surface). Students then discuss the idea of an “entropic tradeoff” in which structure can emerge and entropy may be reduced in the system while at the same time increasing in the environment. The talk will describe the curriculum as well as student performance on computational inquiry projects and assessment tasks that evaluate their use of thermal physics principles when explaining structure formation in biological systems.

**AG02: 9:00-9:30 a.m. Exploring the Relevance of Physics for Students in IPLS Classrooms**

Invited – Abhilash Nair, Michigan State University, 1310 BPS, 567 Wilson Rd., East Lansing, MI 48823; nairabhi@msu.edu

Vashti Sawtelle, Michigan State University

A stated goal of many Introductory Physics for the Life Sciences classrooms is to make physics more relevant to life science students. At Michigan State University we have created a course, BLiSS physics, which is ideal for evaluating the success of this goal. In this talk, I trace my work using case studies of student experiences to explore the relevance of physics to life science majors through three different scales. First we look at a project-based assignment in which students in the course research, build, and critically examine a spirometer, a biomedical device that measures lung capacity with a complex and troubling history. We then explore how positioning life science students as disciplinary experts can strengthen students’ sense of relevance by providing space to bring in outside knowledge. Lastly, we look beyond the two-semester experience at lasting effects as students in the course move into instructional roles as learning assistants.

**AG03: 9:30-10:00 a.m. Do Connections Persist? Assessing the Longitudinal Impact of IPLS**

Invited – Benjamin Geller, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; bgeller1@swarthmore.edu

Chandra Turpen, University of Maryland, College Park

Nathaniel Peters, Jonathan Solomon, Catherine H. Crouch, Swarthmore College

Two primary motivations for IPLS curricula are (1) to better equip life science students with skills that will be important in their later biology course and research experiences; and (2) to foster the belief that physics is relevant and connected to the life sciences. Although efforts have been made to assess whether these goals are being met within the IPLS classroom itself, little if any work has been done to assess the impact of an IPLS course on students’ later biology coursework. In this talk we describe the challenge of designing an exploratory study that compares student reasoning in intermediate biology courses between students with and without IPLS, and we present our initial findings. We analyze student written work from upper division biology courses, case study interviews of students progressing through their post-IPLS experiences, and journal entries in which students reflect on disciplinary connectedness.

**AG04: 10:00-10:30 a.m. Modeling and Simulation for the Life Sciences**

Poster – Peter Hugo Nelson, Guilford College, 4512 Grendel Rd., Greensboro, NC 27410; [pete@circle4.com](mailto:pete@circle4.com)

Life-science students are introduced to modeling and simulation on day one using a physical “marble game” modeling diffusion. Students then work through a self-study guide introduction to Excel and write their own kinetic Monte Carlo (kMC) simulation of the marble game in a blank spreadsheet. In this guided-inquiry exercise, students discover that Fick’s law of diffusion is a consequence of Brownian motion. Subsequent activities introduce students to: algorithms and computational thinking; drug elimination and radioactivity; semi-log plots; finite difference methods (and calculus); the principles of scientific modeling; model validation and residual analysis. Thermodynamics is introduced using kinetic models of osmosis, ligand binding, ion channel permeation and phase equilibria. IPLS students without calculus are not afraid of Excel. They have been able to implement Monte Carlo and finite difference models of topics that usually require ODEs and PDEs. Sample chapters are available for free at <http://circle4.com/biophysics/chapters>

**AG05: 10:00-10:30 a.m. New Development of Physics Courses Optimized for Life Science Majors**

Poster – George B. Trammell, University of California - Los Angeles, 475 Portola Plaza, Los Angeles, CA 90095-1547; [gtrammell@physics.ucla.edu](mailto:gtrammell@physics.ucla.edu)

Katsushi Arisaka, Elizabeth Mills, Joshua Samani, Shanna Shaked, University of California - Los Angeles

Beginning with extensive course development over two years, and pilot courses offered beginning in fall 2017, the University of California - Los Angeles (UCLA) Physics & Astronomy program has implemented a new Introductory Physics for Life Sciences (IPLS) series representing a crucial undergraduate education program serving ~1800 students/year. This effort has resulted in the introduction of new courses, the parallel development of new and modern biologically oriented lab experiments, as well as lecture demonstrations, all with an emphasis on evidence-based pedagogical methods. We summarize our efforts so far and present an analysis of available assessment data.

**AG06: 10:00-10:30 a.m. Transitioning a 300-student IPLS Course to Team-based Learning**

Poster – Brokk K. Toggerson, Physics Department, 666 N. Pleasant St., Amherst, MA 01003-0001; [toggerson@physics.umass.edu](mailto:toggerson@physics.umass.edu)

Over the past years, we at UMass-Amherst have been transitioning six 100-student sections of a first-semester introductory physics for life science (IPLS) course into a team-based (TBL) model following Michaelsen et al. Here we present an overview of our first efforts to teach the second semester of the sequence in the same style. Due to institutional constraints, the second semester of the sequence has 300 students per section and is taught in a traditional lecture hall. A discussion of how we handled some of the logistical challenges of teaching in a TBL mode in this space will be touched upon along with a discussion of the particular IPLS features and some notes on future plans

**AG07: 10:00-10:30 a.m. Application of Team-based Learning to a First Semester IPLS Course**

Poster – Brokk K. Toggerson, University of Massachusetts, Amherst, Department of Physics, 666 N. Pleasant St., Amherst, MA 01003-0001; [toggerson@physics.umass.edu](mailto:toggerson@physics.umass.edu)

Heath Hatch, Christopher Ertl, Paul Bourgeois, University of Massachusetts, Amherst

We present the current status of an effort at UMass, Amherst to transition the first semester of our large IPLS course to a team-based learning format following Michaelsen et al. while simultaneously adjusting the topics and skills covered to apply to our population. We will present our motivations for the transition, key features of our course’s structure, and an overview of the largest departures in content from a typical algebra-based introductory course. We will also discuss new developments towards a dedicated free and open-source textbook for our course based upon the OpenStax College Physics text.

**AG08: 10:00-10:30 a.m. Creating a Survey on Moving Fluids for Life Science Students**

Poster – Dawn Meredith, University of New Hampshire, 9 Library Way, Durham, NH 03824; [dawn.meredith@unh.edu](mailto:dawn.meredith@unh.edu)

James Vesenka, University of New England

Daniel Young, University of North Carolina

Rebecca Lindell, Tiliadel STEM Education Solutions

We present several questions and student-generated distractors for a conceptual survey on moving fluids that is currently under development. This survey is aimed at life students and focuses on concepts of viscosity (including Hagen-Poiseuille law), Reynolds number, continuity, flow rate, and Bernoulli’s principle.

**AG09: 10:00-10:30 a.m. Investigating Students’ Resources on Diffusion with Experimental and Computational Activities**

Poster – Daniel P. Weller, \* Michigan State University, 9347 Bennett Lake Road, Fenton, MI 48430-8731; [wellerd2@msu.edu](mailto:wellerd2@msu.edu)

Kathleen Hinko, Vashti Sawtelle, Michigan State University

At Michigan State University, we have created an Introductory Physics for the Life Sciences course that utilizes the studio model of physics, with a particular focus on the topic of diffusion. As part of this course, we developed an experimental microscope activity to complement a computational activity that models the diffusive motion of particles in solution. In this microscope activity, students would form a hypothesis about the motion of various microbead solutions and design an experiment to validate these hypotheses. We present work that analyzes student responses to pre- and post-lab questions from a resource theory perspective. Specifically, we present findings highlighting how students perceived the realistic or idealistic nature of the two activities. This work forms the foundation for combining physical lab activities with computational modeling in a way that maximizes student engagement and comprehension.

\*Sponsored by Kathleen Hinko and Vashti Sawtelle

**AG10: 10:00-10:30 a.m. IPLS at Georgia Tech**

Poster – Nicholas C. Darnton, Georgia Institute of Technology, 837 State St. NW, Atlanta, GA 30330; [ndarnton@gatech.edu](mailto:ndarnton@gatech.edu)

JC Gumbart, Jennifer Curtis, Georgia Institute of Technology

Georgia Tech recently implemented a new IPLS “flavor” of our calculus-based introductory physics sequence. In adapting the University of Maryland, College Park framework to our target audience (biology, chemistry and neuroscience majors), we increased the number of online and written problems while reducing the scope of labs to allow for longer recitation sessions. Anecdotally, we observe enthusiasm for this approach, with enrollment growing with each subsequent offering. However, problems arise for students switching between IPLS and the traditional sequence mid-year.

## Session AI: Panel – Learning More About Getting Involved in AAPT Committee Work: A Primer

Location: Marriott Marquis - Silver Linden Sponsor: AAPT Time: 8:30–10:30 a.m. Date: Monday, July 30 President: Gordon Ramsey

*In this session, AAPT participants can learn more about AAPT's diverse committees and the work they conduct to assist the AAPT in meeting its objectives. Area Chairs or Vice Chairs will introduce their committees and answer questions from participants about becoming more involved in committee work.*

## Session AJ: Physics and Product Innovation

Location: Marriott Marquis - Scarlet Oak Sponsor: Committee on the Interests of Senior Physicists

Co-Sponsor: Committee on Apparatus Time: 8:30–10:30 a.m. Date: Monday, July 30 President: David Donnelly

### AJ01: 8:30-9:00 a.m. What Good is an Electro-Magnetic Wave? Patents and Strategies in the Early Development of Radio, 1860-1920

*Invited – W. Bernard Carlson, \* University of Virginia, Department of Engineering and Society - School of Engineering and Applied Science, 351 McCormick Road P.O. Box 400744, Charlottesville, VA 22904-4744; wc4p@virginia.edu*

While we often narrate the development of radio as a straightforward path from Maxwell's prediction of electromagnetic waves in the 1860s to the introduction of radio broadcasting circa 1920, the actual path from the laboratory to the marketplace was much more convoluted, and indeed, more interesting. This paper explores how physicists, inventors, and engineers all had different ideas about how to create new technology that employed electromagnetic waves. In particular, I will discuss the rivalry between Nikola Tesla and Marconi, with side glances at Michael Pupin and Lee De Forest. Overall, the paper will reveal the creative energy needed to link discovery to commercialization.

\*Sponsored by Jill Marshall

### AJ02: 9:00-9:30 a.m. Neglected Stories of African Americans in Science and Invention

*Invited – Gregory Good, American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3843 gggood@aip.org*

All science teachers know that African Americans are underrepresented among scientists and engineers. Policy people want to increase these numbers. What can history of science uniquely offer to catch the attention of a student of an underrepresented minority? History offers, quite simply, stories. Through identifying many African Americans who have been scientists and inventors and through exploring their challenges, their successes, and their science and innovation, historians can provide images that young African Americans can identify with. This talk will introduce the more than 50 lesson plans on the AIP Center for History of Physics website – under Teaching Guides on Women and Minorities – and in the AIP History of Science Web Exhibits. The focus of this talk will be to help teachers explore the stories of African Americans who have contributed to science and innovation.

### AJ03: 9:30-10:00 a.m. The Protective Rights of Intellectual Property Ownership

*Invited – Zandra Smith, \* United States Patent and Trademark Office, 600 Dulany St., Alexandria, VA 22314; Zandra.Smith@USPTO.GOV*

The protective rights of intellectual property ownership can provide safeguards against competitor infringement, ensure brand recognition and distinguish the brand from all other goods and services offered to customers nationwide. Learn the basics of patents, trademarks, and copyrights with an in-depth discussion relating to all aspects of the patenting process. The presentation will provide an overview of the types of patents, parts of a patent applications, the examination process, claim analysis with respect to novelty and obviousness, and the understanding an office action.

\*Sponsored by David Donnelly

### AJ04: 10-10:30 a.m. Trademarks – Keys to Commercialization for Any New Inventions

*Invited – Craig Morris, \* Office of the Commissioner for Trademarks U.S. Patent and Trademark Office, USPTO Madison Building, 600 Dulany Street, Alexandria, VA 22314; craig.morris@uspto.gov*

Protecting an invention is one thing---and critical. But commercializing that invention, that is, successfully taking it to market, is another important step. This program highlights how trademarks are critical “keys” in that overall process.” It starts by discussing what trademarks are and how they differ from domain names and business name registrations. It then explains the importance of selecting a strong mark, that is, one that is both federally registrable and legally protectable. It highlights factors important when choosing a mark, such as the possibility of a likelihood of confusion, and explains the importance of searching and whether to use an attorney. Finally, it establishes what may happen if another trademark owner believes it has stronger rights in a mark and issues a “cease-and-desist” letter. It concludes with information on how to avoid “scams” perpetrated by companies that request fees for services that the USPTO does not require.

\*Sponsored by Jill Marshall

## Session AK: PTRA: Make, Play, Do

Location: Congressional Ballroom A

Sponsor: Committee on Physics in Pre-High School Education Time: 8:30–10:30 a.m. Date: Monday, July 30 President: Gene Easter

### AK: 8:30-10:30 a.m. PTRA: Make , Play, Do

*Invited – William Reitz, 2921 Kent Rd., Silver Lake, OH 44224; wreitz@neo.rr.com*

Join in the fun as we construct science equipment exemplifying one of the most effective ways for K-12 students to learn: Active Engagement. Our crackerjack panel will kick-off this round-robin style share-a-thon with engaging “make n take” projects complete with excellent support activities. Participants will construct their own apparatus with materials provided. Also, participants are highly encouraged to contribute their favorite classroom activities. Please bring sufficient materials and instructions to share with 25 other teachers.

*This session focuses on the use of stories to accurately communicate scientific information. Stories can be a powerful and therefore useful means of communicating through fostering multiple ways for the reader to connect with the content. This can be used to communicate with a variety of audiences, particularly younger audiences. The panel will include authors who will discuss their experiences writing stories for reaching a broader audience. The session will conclude with a brief exercise for the attendees to practice this type of writing.*

**AM01: 8:30-9:00 a.m. The Next Gen PET Curriculum and Online Faculty Community\***

*Invited – Edward Price, California State University San Marcos, 333 South Twin Oaks Valley Road, San Marcos, CA 92096; eprice@csusm.edu*

What can we learn from an online community of 50 instructors using a shared curriculum, collecting data on student learning, and seeking to improve their instruction? This talk will present initial findings from such an effort. The Next Generation Physical Science and Everyday Thinking (Next Gen PET) Faculty Online Learning Community (FOLC) has the goals of supporting faculty development that will result in far-reaching, sustainable educational transformation, and serving as a “laboratory” for studying student learning. The community includes experts who serve as facilitators, an internal structure of faculty clusters, and supporting communication tools. Faculty in the community are teaching physics or physical science courses for pre-service elementary teachers using the Next Gen PET curriculum. Next Gen PET is a research-based, guided inquiry curriculum for pre-service elementary teachers that is aligned with the Next Generation Science Standards. Versions are available for either small or large enrollments, and addressing either physics or physical science content. This talk will describe the curriculum, the development of the community, student learning outcomes, and how the FOLC supports instructors’ use of research-based instructional practices.

\*This work is supported by the National Science Foundation DUE-1626496

**AM02: 9:00-9:10 a.m. My Experiences Using the NextGenPET Curriculum and Joining a FOLC**

*Contributed – M. Lynn Lucatorto, James Madison University, MSC 4502, 901 Carrier Dr., Harrisonburg, VA 22807; lucatolx@jmu.edu*

The Next Generation Physics and Everyday Thinking (Next Gen PET) curriculum has been used in classrooms for both pre-service elementary teachers and general student populations at James Madison University beginning in the fall semester of 2017. Next Gen PET was selected because of its research-based, active learning focus. Students’ prior exposure to physics and chemistry ranged from AP Physics/Chemistry to none. This talk focuses on two areas: how I found and implemented Next Gen PET curriculum and how my participation as a member of the Next Gen PET Faculty Online Learning Community (FOLC) has had benefits both in terms of utilizing the curriculum for my students and for my professional development as an instructor.

**AM03: 9:10-9:20 a.m. Planning and Carrying Out Investigations in the NextGen PET Curriculum\***

*Contributed – Paul M. Miller, West Virginia University, PO Box 6315, Morgantown, WV 26506-6315; paul.miller@mail.wvu.edu*

*Kathleen Koenig, University of Cincinnati*

*Lynn Michaluk, Melissa J. Luna, Fred Goldberg, San Diego State University*

The Next Generation Physics and Everyday Thinking (Next Gen PET) curriculum is a research-based, NGSS-aligned curriculum for pre-service elementary teachers. This talk focuses on the NGSS practice of Planning and Carrying Out Investigations, a practice that is not currently supported in the published Next Gen PET curriculum. To address this omission, we developed materials in the Next Gen PET format that focus on this practice and that can be optionally included in a Next Gen PET. We piloted those materials during a fall 2017 implementation of the PET curriculum and administered a new assessment before and after instruction. The lead author is a participant in Next Gen PET Faculty Online Learning Community (FOLC), which has provided a community in which these materials can be shared and improved.

\*Funding for this project comes from NSF DUE-1611738.

**AM04: 9:20-9:30 a.m. Adapting the Next Generation PET Curriculum for a Lecture-Laboratory Format\***

*Contributed – Gay B. Stewart, West Virginia University, Department of Physics, Morgantown, WV 26506-6315; gbstewart@mail.wvu.edu*

*Paul Miller, West Virginia University*

*Fred Goldberg, San Diego State University*

The Next Generation Physical Science and Everyday Thinking (Next Gen PET) grew from Physics and Everyday Thinking (PET) and has been shown to significantly impact both future teacher content knowledge and understanding of how students learn science. It has been taught at two-year and four-year institutions, adapted for science methods courses in schools of education, and offered as a workshop for practicing elementary teachers. Although it is offered in two versions, designed exclusively for either studio style or lecture style settings, it did not fit the common lab/lecture format that fulfills general education requirements at many colleges. We have developed an implementation of existing materials to support the lecture/lab model. In this talk, we report on our experiences with a hybrid implementation of Next Gen PET.

\*Funding for this project comes from NSF DUE-1611738.

**AM05: 9:30-9:40 a.m. PEER Suite: Transforming Courses, Engaging Teachers, and Assessing Multiple Dimensions**

*Contributed – Valerie Otero, University of Colorado Boulder, 249 UCB Boulder, CO 80309-0390; valerie.otero@colorado.edu*

*Shelly Belleau, University of Colorado Boulder*

The Physics through Evidence: Empowerment through Reasoning (PEER) Suite addresses contextual aspects of districts, courses, and teacher needs through a suite of materials intended to empower students through scientific practices. Our Suite T-E- A philosophy establishes long term partnerships leading to teacher community, pedagogical growth, and student success. T-Transforming Classrooms involves adaptable curriculum materials, guides, and a website that supports supplementing

activities and creating storylines through engineering design challenges and other phenomena. E-Engaging Teachers is a community of PEER teachers that meets for several years to hone their practice for their specific contexts. Targeted professional development materials are intended for practice-based reflection/planning and building theoretical and philosophical underpinnings. A-Assessing Multiple Dimensions provides 3-D performance assessments as well as pre/post assessment materials and attitudinal assessments for meeting district goals. We will discuss the PEER Suite, show data regarding its effectiveness, and describe our district and teacher partnerships that make it all work.

### AM06: 9:40-9:50 a.m. Three Dimensional Assessment in High School Physics

Contributed – Shelly Belleau, University of Colorado Boulder, 249 UCB Boulder, CO 80309-0390; Shelly.Belleau@gmail.com

Even the simplest of assessments are challenging for physics students, and new efforts to create “three-dimensional assessments” present an even greater challenge. The Physics through Evidence: Empowerment Through Reasoning ) project (formerly PET-HS) has engaged in developing 3D assessments to match curricular goals and has built a vast bank of resources to support teachers assessing student understanding, both formatively and summatively. Resources include 3D assessment tools that assess student learning on physics content, practices, and crosscutting concepts as well as engineering design challenges where students actively apply their physics understanding to design a solution to a proposed problem. In this session we will share our strategies for developing these types of assessments for the high school context in addition to the ways we generate rubrics and provide grades.

## Session AN: Astronomy

Location: Meeting Room 5 Sponsor: AAPT Time: 8:30–9:20 a.m. Date: Monday, July 30 President: Ken Brandt

### AN01: 8:30-8:40 a.m. Undergraduate Course

Contributed – Vladimir I. Tsifrinovich, \* NYU Tandon School of Engineering, Department of Applied Physics, Brooklyn, NY 11201; vtsifrin@nyu.edu

I would like to share my experience in development and teaching an undergraduate course “Introduction to Cosmology”. While cosmology is one of the most popular topics in science and the idea of “Big Bang” is well known to the general public I was surprised to see that students actually do not understand the scientific meaning of modern cosmology. The major problem I face is to explain what do we mean under the modern cosmology? Many students believe that we really wish to describe the infinite world at an infinite spatial and time scale and even answer the theological question. I have to explain that modern cosmology describes the Universe on a definite spatial and temporal scale. The current cosmological scale is definitely greater than that in the ancient or even 19th century cosmology but it is still finite. It is important to explain that at every new scale we have a new picture of the Universe as well as new mathematical models to describe that picture. So, I have to explain that the previous cosmological models starting from the ancient ones were not wrong. They described the Universe at the scale available at that time. They became wrong or even ridiculous only when people tried to extend those models to a larger scale without reliable information about the Universe on that scale. The same is true for the modern cosmology.

\*Sponsored by Genrikh Golin.

### AN02: 8:40-8:50 a.m. A Student-Generated Embodied Metaphor for Binary Star Dynamics

Contributed – Elias Euler, Uppsala University, Ångströmlaboratoriet, Lägerhyddsvägen 1 Uppsala, 75120 Sweden; elias.euler@physics.uu.se

Elmer Rådahl, Bor Gregoric, Uppsala University

In this presentation, we present an example of a student-generated metaphor for celestial motion in the form of an embodied dance. We examine how this dance played a part in the students’ reasoning about astronomy, paying particular attention to how the students coordinated the movements of their bodies to communicate with one another about the centrality and reciprocity of the interactions between binary stars. We also consider how an open-ended, technology-rich learning environment made such a metaphorical, embodied representation possible, and review how the process of unpacking such metaphors can be embraced by teachers in potentially fruitful ways.

### AN03: 8:50-9:00 a.m. Astronomy Outreach Done Right: Ten Year Anniversary of Phoenix Landing on Mars

Contributed – Ken Brandt, Robeson Planetarium and Science Center, 8501 Independence Dr., Hope Mills, NC 28348; brandt@uncp.edu

The Phoenix mission outreach team did a masterful job of engaging audiences through their outreach plan and delivery. This talk looks back on that success from an institutional point of view. Also presented will be an overview of the mission and its discoveries.

### AN04: 9:00-9:10 a.m. Once in a Blue Moon, Space Explores You!

Contributed – Jordan K. Steckoff, University of Texas at Austin, 2234 East North Territorial Road, Whitmore Lake, MI 48189; steckloff@utexas.edu

Astronomy education often takes place in formal education settings. However, the cosmos periodically produces an event that engages a broad swath of the community, and provides a tool to informally engage the broader public. The Hamburg Meteoroid entered Earth’s atmosphere shortly after 8 p.m. on Jan. 16, 2018, producing a shock wave equivalent to ~10 tons of TNT, and rained meteorite across the frozen lakes of Hamburg Township, Michigan. The resulting meteorite strewn field was soon swarming with professional and amateur meteorite hunters and curious families. Here I present the astronomy education and public outreach opportunities that this event created, which allowed me to engage the public in an informal setting. This “field trip” allowed these learners to investigate the physics of meteorites, such as how the atmosphere sorts meteorites by size, why the meteorites were cold to the touch, and why 11 km/s is “slow”.

### AN05: 9:10-9:20 a.m. Lessons Learned in Learning to Research

Contributed – David Oparko, Stanford Online High School, 1617 Cross Way, San Jose, CA 95125-1217; dcooparko@stanford.edu

Through the Institute for Student Astronomical Research (InStAR) we are able to collaborate with other institutes with a common purpose of educating students in the process of astronomical research. At Stanford Online High School our end goal for students in our Astronomy Research Seminar is to write, revise, and submit a manuscript for publication to a journal such as the Journal of Double Star Observations (JDSO). Data is gathered through robotic telescopes which allows remote observing and coincides with our virtual meeting nature. Learning to research within a group and independently can be a difficult skill to develop but is greatly

valued. Areas that may indicate how a student may do are linked to their previous research experience, class size, group size, and class structure. With these possible predictors we have gained an increased understanding of our pitfalls and successes to improve the Research Seminar at Stanford's Online High School.

## Session A0: Gender

**Location:** Congressional Ballroom B    **Sponsor:** AAPT    **Time:** 9:30–10:20 a.m.    **Date:** Monday, July 30    **President:** Toni D. Sauncy

### A001: 9:30-9:40 a.m. Large Gender Differences in Physics Self-Efficacy at Equal Performance Levels: A Warning Sign?

*Contributed – Zeynep Y. Kalender, Department of Physics and Astronomy, University of Pittsburgh, 2000 Wendover St., apt 3, Pittsburgh, PA 15217; zyk2@pitt.edu*

*Emily Marshman, Chandralekha Singh, Department of Physics and Astronomy, University of Pittsburgh*

*Timothy Nokes-Malach, Chris Schunn, Learning Research and Development Center, University of Pittsburgh*

Self-efficacy, or the belief in one's capability to succeed in a particular task, course, or subject area, has been shown to influence students' learning outcomes. Previous studies have shown that female students have lower self-efficacy than males in physics courses. However, few studies have focused on self-efficacy gender differences at equal performance levels. Differences in self-efficacy for similarly performing males and females can have detrimental short-term and long-term effects. Across two different introductory courses with many different instructors and pedagogies, we uncover large self-efficacy differences between female and male students performing similarly on standardized physics conceptual tests or who received the same course letter grade in physics. We thank the National Science Foundation for support.

### A002: 9:40-9:50 a.m. Evaluating the Gender Gap within Introductory Mechanics at TAMU

*Contributed – Jonathan D. Perry, Texas A&M University, 4242 TAMU, College Station, TX 77843-0001; JPerry@physics.tamu.edu*

*Tatiana L. Erukhimova, William H. Bassichis, Texas A&M University*

Gender bias in introductory physics courses has been observed previously for in-course metrics (homework, participation, exams), final course grades, and conceptual assessments. Disparities in final course grades are often attributed to a small gender gap in exam performance. This gap, however, is not generally examined in detail within the course itself to determine if they are transient or persistent effects. This work examines the gender-based performance gap between in-course metrics, particularly mid-term exams, and final course grades. The data for this study covers STEM majors enrolled in the calculus-based introductory physics sequence at Texas A&M University between 2008-2016. Performance gap based on gender will be examined for each mid-term given to students over these years and compared to the gap in final grades to determine the consistency of this bias. Additional bias of instructor gender relative to mid-term exam and final course grades will also be studied.

### A003: 9:50-10:00 a.m. Impact of Evidence-based Active-Engagement Instruction on the Gender Gap in Introductory Physics\*

*Contributed – Alexandru Maries, University of Pittsburgh, 3405 Telford St., Cincinnati, OH 45220; mariesau@ucmail.uc.edu*

*Nafis I. Karim, Chandralekha Singh, University of Pittsburgh*

Prior research suggests that some evidence-based pedagogies may result in both improved learning for all students, as well as a reduction in the gender gap. We describe the impact of evidence-based active engagement (EBAE) strategies on the gender gap observed on validated conceptual surveys. We compare male and female students' performance in EBAE courses with courses that primarily use lecture-based (LB) instruction. All courses had large enrollment and often had more than 100 students. We find that students in courses which make significant use of evidence-based active engagement strategies, on average, significantly outperformed students in courses of the same type using primarily lecture-based instruction even though there was no statistically significant difference on the pretest before instruction. However, the gender gap persisted even in courses using EBAE methods. \*Work supported by the National Science Foundation.

\*Work supported by the National Science Foundation

### A004: 10:00-10:10 a.m. Impact of Psychological Interventions on Gender Gaps in Introductory Studio Physics

*Contributed – Bethany R. Wilcox, Colorado School of Mines, 2510 Taft Dr. Unit 213, Boulder, CO 80302; brwilcox@mines.edu*

*Kristine Callan, Colorado School of Mines*

Implementation of interactive engagement has been shown as an effective strategy to reduce performance gaps for underrepresented groups of students; however, interactive engagement alone is often not sufficient to remove these gaps completely. In the context of a highly interactive, introductory studio physics course, we still see a significant gender gap on both pre- and post-instruction conceptual inventories, exams, and occasionally, final grade. We have previously investigated the impact of varying group composition within the studio environment, but have yet to observe statistically significant reductions in the size of the gender gap. In conjunction with this work, we have implemented other strategies for reducing performance gaps, including psychological interventions targeting students' sense of belonging and growth (vs. fixed) mindset. Here, we describe our implementation of these interventions and preliminary evidence for their effectiveness with respect to reducing the gender gap within our introductory studio physics course.

### A005: 10:10-10:20 a.m. Persistence and Career Choices of Female Finnish University Students

*Contributed – Alexis V. Knaub, Michigan State University, Department of Physics and Astronomy, East Lansing, MI 48824; avknaub@gmail.com*

*Ramon Barthelemy, Solutions for Policy, Washington DC*

Finland is often seen and admired as an equity and education-focused country. They have policies that champion gender equity and a world-renowned K-12 education system, with students ranking among the top on international metrics. However, little is known on whether these policies and early education experiences support gender equity in postsecondary education and beyond, particularly in fields that struggle to support women. We conducted a study on Finnish physics students enrolled in Finnish universities using the Science Motivation Questionnaire. In this talk, we will discuss the results of this study with respect to gender and differences in persistence and career choices.

**Session AP: Interactive Lecture Demonstrations: Whats New? ILDs Using Clickers and Video Analysis** Location: Meeting Room 4  
Sponsor: Committee on Research in Physics Education Co-Sponsor: Committee on Educational Technologies Time: 9:30–10:30 a.m. Date: Monday, July 30  
President: Priscilla Laws

**AP01: 9:30-10:00 a.m. Interactive Lecture Demonstrations: Whats New? ILDs Using Clickers and Video Analysis**

Invited – David Sokoloff, Department of Physics, 1274 University of Oregon, Eugene, OR 97403-1274; sokoloff@uoregon.edu

Ronald K. Thornton, Tufts University

The results of physics education research and the availability of microcomputer-based tools have led to the development of the Activity Based Physics Suite. (1) Most of the Suite materials are designed for hands-on learning, for example student-oriented laboratory curricula such as RealTime Physics. One reason for the success of these materials is that they encourage students to take an active part in their learning. This interactive session will demonstrate through active audience participation Suite materials designed to promote active learning in lecture-Interactive Lecture Demonstrations (ILDs) (2), including those using clickers and video analysis.

1. E.F. Redish, Teaching Physics with the Physics Suite (Wiley, Hoboken, NJ, 2004). 2. David R. Sokoloff and Ronald K. Thornton, Interactive Lecture Demonstrations (Wiley, Hoboken, NJ, 2004).

**AP02: 10:30-10:30 a.m. Interactive Lecture Demonstrations: Effectiveness in Teaching Concepts**

Invited – Ronald K. Thornton, Tufts University, Departments of Physics and Education, Medford, MA 02155; ronald.thornton@tufts.edu

David R. Sokoloff, University of Oregon

The effectiveness of Interactive Lecture Demonstrations (ILDs) in teaching physics concepts has been studied using physics education research based, multiple-choice conceptual evaluations.(1) Results of such studies will be presented, including studies with clicker ILDs. These results should be encouraging to those who wish to improve conceptual learning in their introductory physics course.

1. David R. Sokoloff and Ronald K. Thornton, "Using Interactive Lecture Demonstrations to Create an Active Learning Environment," Phys. Teach. 35, 340 (1997).

**Session TOP01: Early Career Topical Discussion** Location: Meeting Room 2 Sponsor: Committee on Research in Physics Education  
Co-Sponsor: Committee on Professional Concerns Time: 8:30–10:30 a.m. Date: Monday, July 30 President: Daryl McPadden

*Postdocs, new faculty, and other junior Physics Education Research (PER) members are invited to this topical discussion to meet and discuss common issues. As this stage in a career can be a period of significant transition, we are hoping to provide a space to facilitate community building, resources, and professional development for those starting a career in PER.*

**Session TOP02: Explore Your Concept Inventory Data with the PhysPort Data Explorer**

Location: Meeting Room 3 Sponsor: AAPT Time: 8:30–10:30 a.m. Date: Monday, July 30 President: Sam McKagan

*Do you give concept inventories such as the FCI, FMCE, BEMA, CSEM, CLASS, or MPEX in your class? Do you need help analyzing and making sense of data from these assessments? Are you curious what kinds of patterns are in your data? Would you like to compare your students' results to national averages? The PhysPort Data Explorer ([www.physport.org/dataexplorer](http://www.physport.org/dataexplorer)) can help you with all this and more. In this session, the creators of the Data Explorer will provide an overview of what it can do, answer questions, and if you bring a laptop with some data on it, show you how you can use the tool to get instant analysis and visualization of your own data.*



## Paul W. Zitzewitz Award for Excellence in K-12 Physics Teaching to Frank Noschese



**Frank Noschese**  
John Jay High School,  
Cross River, NY

### #iTeachPhysics – Can Social Media Make Us Better Educators?

Social media has moved beyond status updates about breakfast and is changing how we engage in our profession as educators. Social media allows classroom teachers to connect with each other and share lesson ideas. But social media can also evoke empathy — allowing us to see the previously unknown personal and professional struggles of others. It can transform our perceptions about our students and colleagues and thus spark action to seek change within ourselves and within our institutions.

## David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching to Bradley S. Ambrose



**Bradley S. Ambrose**  
Grand Valley State  
University, Allendale, MI

### We Teach More Than Physics

For me the enterprise of teaching physics, whether for non-science majors, physics majors, high school teachers, or college and university faculty, has always been guided by lessons learned from my experience working in the physics education research (PER) community. Among the innumerable insights that my colleagues in PER have striven to share, much of their work has helped us all discern more clearly the impact that our teaching can (and should) have on our students. For example, we naturally aim for our students to build for themselves a robust conceptual understanding of physics, and we want them to develop into increasingly sophisticated problem solvers. However, in addition, we can help (or hinder) our students' understanding of science as a human endeavor; we can help them become more effective communicators with us and with their peers; and we can help them learn how they themselves learn. Along these lines, I intend during this presentation to reflect upon how we all teach more than “just” physics—in ways that may already seem familiar, and hopefully in other ways that will expand this notion a bit further.

## PhysTEC Teacher of the Year Awarded to Tiffany Taylor



**Tiffany Taylor**  
Rogers Heritage H.S.  
Rogers, AR

Tiffany Taylor is named the 2018 National PhysTEC Teacher of the Year. The selection committee noted her success as a teacher of AP Physics classes, as well as 9th grade physical science. She graduated from the University of Arkansas with a BA in physics and spent her first year teaching 7th grade science at Pea Ridge Middle School. She has been at Rogers Heritage High School for 7 years, teaching physical science and AP Physics. She is also head softball coach at Heritage.

“I love teaching, and I really love teaching physics! I love learning about the world around me, and sharing that passion with my students.”

## Session BA: PER: Interdisciplinary Studies and Support, and Curriculum and Instruction

Location: Marriott Marquis - Tulip Sponsor: AAPT/PER Time: 1:30–3:30 p.m. Date: Monday, July 30 President: Brian Pyper

### BA01: 1:30-1:40 p.m. Contributing to a Web Portal for Sharing Curricular Materials\*

Contributed – Adrian Madsen, American Association of Physics Teachers, 1100 Chokecherry Lane, Longmont, CO 80503; [adrian.m.madsen@gmail.com](mailto:adrian.m.madsen@gmail.com)

Sarah B. McKagan, American Association of Physics Teachers

Mathew Martinuk, Rachel Price, Theresa Neil Strategy + Design

Dawn Meredith, Joe Redish, Chandra Turpen, Remy Dou, Lyle Barbato, and Michael Thenhaus

In this talk we present our new user-friendly system for contributing your materials to the Living Physics Portal. The Portal is a new web resource created by AAPT and eight colleges and universities, where physics educators can share and discuss curricular materials for teaching introductory physics for life sciences (IPLS). The Portal supports sharing of materials with grain sizes ranging from full courses, to smaller modules and collections, to individual items like homework questions. It also supports editorial review of contributions and community discussions.

\*This work is supported by NSF IUSE # 1624192.

### BA02: 1:40-1:50 p.m. Designing a Web Portal for Sharing Curricular Materials\*

Contributed – Sarah McKagan, American Association of Physics Teachers, 124 28th Ave., Seattle, WA 98122; [sam.mckagan@gmail.com](mailto:sam.mckagan@gmail.com)

Adrian Madsen, American Association of Physics Teachers

Mathew Martinuk, Rachel Price, Theresa Neil Strategy + Design

Dawn Meredith, Joe Redish, Chandra Turpen, Remy Dou, Lyle Barbato, and Michael Thenhaus

In this talk we present an overview of our research, design and testing process for the Living Physics Portal, the design challenges we encountered, and what we learned from users and how it influenced our designs. To address the many design challenges in creating an easy-to-use online system for instructors to share curricular materials, we created the Portal with a user-centered design process. This process includes research into user needs, developing personas to represent our key users, creating scenarios that will address their most important needs, designing a site focused on workflows through these scenarios, and conducting usability testing to ensure that the final product meets user needs. In this talk, we present an overview of our research, design and testing process, and discuss what we learned from users and how it influenced our designs.

\*This work is supported by NSF IUSE #1624192.

### BA03: 1:50-2:00 p.m. Building Educational Websites – Insights From Expert Developers\*

Contributed – Raluca Teodorescu, Montgomery College, 7600 Takoma Ave., Takoma Park, MD 20912; [raluca.teodorescu@montgomerycollege.edu](mailto:raluca.teodorescu@montgomerycollege.edu)

Edward F. Redish, University of Maryland

Mark Reeves, George Washington University

Sarah B. McKagan, American Association of Physics Teachers

As part of the Living Physics Portal Project, we conducted interviews with eight developers of main physics-related educational websites (among them comPADRE, PhysPort, Science Education Initiative, LONCAPA, and Mastering Physics). The interviews focused on critical moments in the websites' development, content handling, searching capabilities, maintenance, and sustainability. We will present the lessons learned, as well as how we plan to put them in practice.

\*This work is supported by NSF IUSE # 1624192.

### BA04: 2:00-2:10 p.m. Assessing the Lasting Impact of an IPLS Course

Contributed – Jonathan Solomon, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; [bgeller1@swarthmore.edu](mailto:bgeller1@swarthmore.edu)

Catherine H. Crouch, Benjamin Geller, Nathaniel Peters, Katherine Lima, Swarthmore College

Introductory Physics for Life Science (IPLS) courses seek to equip life science students with skills and reasoning strategies that will be important for their later work in upper-level biology courses and biology research environments. To assess whether IPLS courses are actually meeting this goal, we assess the written work of students in biology courses taken after the IPLS experience. In examining these data, we look for evidence of (1) quantitative reasoning, (2) facility coordinating between biological systems and simple physical models, and (3) mechanistic reasoning. We compare these results to results from the work of students who had not experienced the IPLS environment.

### BA05: 2:10-2:20 p.m. When Epistemological Progress in Physics Doesn't Transfer: Implications for IPLS

Contributed – Julia S. Gouvea, \* Tufts University, 201 Paige Hall, Department of Education, Medford, MA 02155; [julia.gouvea@tufts.edu](mailto:julia.gouvea@tufts.edu)

Vashti Sawtelle, Abhilash Nair, University of Michigan

Epistemology-oriented reforms have been successful in fostering more sophisticated approaches to knowing and learning in physics. A broader goal of these reforms is that epistemological progress in physics will transfer to other contexts. In this talk we present a case study of a biology major, Philip, who made epistemological progress in a year-long introductory physics course for the life sciences (IPLS) by seeking meaning and coherence, talking through inconsistencies, and studying for understanding. Philip reported not applying these strategies in his biology courses. This result is surprising given that at the beginning of the year Philip described learning for understanding as an approach that he expected to work in both physics and biology. We argue that the major barrier to transfer was a lack of connection between the two disciplinary contexts and discuss the implications for a more holistic approach to undergraduate science education reform.

\*Sponsored by David Webb

### BA06: 2:20-2:30 p.m. Got Anything non-Cartesian?: An Analysis of Multivariable Calculus Textbooks

Contributed – Chaelee Dalton, \* Pomona College, 170 E 6th St., Claremont, CA 91711; [chaelee.dalton@pomona.edu](mailto:chaelee.dalton@pomona.edu)

Brian Farlo, Warren Christensen, North Dakota State University

Upper-division undergraduate physics coursework necessitates a grasp of mathematical knowledge from students' prior coursework in mathematics. Published literature suggests that student understanding of non-Cartesian coordinate systems is weak in mathematics and physics contexts (Moore et al, 2014; Sayre and Wittman 2007). This study examines seven Multivariable Calculus textbooks as sources that can potentially enable student understanding of non-Cartesian coordinate systems. Quantitative content analysis categorized examples, definitions, and problems/exercises according to their coordinate system(s). Results demonstrated that non-Cartesian coordinate system representation was minimal. Only 21% of textbook chapters included a single instance of non-Cartesian coordinates. Of those chapters, only 73% of items coded according to their coordinate systems were Cartesian. Furthermore, these textbooks do not introduce non-Cartesian unit vectors at all. This work casts light on the significant gap that exists between the expectations for students in upper-division physics course and the content they receive in calculus courses.

\*Sponsored by Warren Christensen, North Dakota State University

Moore, K. C., Paoletti, T., & Musgrave, S. (2014). Complexities in students' construction of the polar coordinate system. *Journal of Mathematical Behavior*, 36, 135-149. Sayre, E.C., & Wittmann, M. C. (2008). Plasticity of intermediate mechanics students' coordinate system choice. *Physical Review: Special Topics- Physical Education Research*, 4, 020105.

### **BA07: 2:30-2:40 p.m. How Do Introductory Physics and Mathematics Courses Impact Engineering Students' Performance in Subsequent Engineering Courses?**

*Contributed – Kyle M. Whitcomb,\* University of Pittsburgh, 3289 Dawson St., Apt. 5, Pittsburgh, PA 15213-4549; kmw136@pitt.edu*

*Zeynep Y. Kalendar, Tim Nokes-Malach, Chris Schunn, Chandralekha Singh, University of Pittsburgh*

In collegiate curricula, physics and mathematics are treated as foundations for many other disciplines including engineering. Using academic data from the cohorts of students in introductory physics since 2010, we investigate the correlation between the performance of undergraduate engineering majors in introductory physics and mathematics courses and their performance in subsequent engineering courses. We find interesting patterns of performance that can help inform curricula for engineering programs. We thank the National Science Foundation for support.

\*Sponsored by Chandralekha Singh

### **BA08: 2:40-2:50 p.m. Using Machine Learning to Predict Integrating Computation into Physics Courses**

*Contributed – Nicholas Young, Michigan State University, 567 Wilson Road, East Lansing, MI 48824; youngn18@msu.edu*

*Marcos D. Caballero, Michigan State University*

Computation is a central aspect of 21st century physics practice; it is used to model complicated systems, to simulate impossible experiments, and to analyze mountains of data. Physics departments and their faculty are increasingly recognizing the importance of teaching computation to their students. We recently completed a national survey of faculty in physics departments to understand the state of computational instruction and the factors that underlie that instruction. The data collected from the 1257 faculty responding to the survey included a variety of scales, binary questions, and numerical responses. We then used supervised learning to explore the factors that are most predictive of whether a faculty member decides to include computation in their physics courses. We find that personal, attitudinal, and departmental factors vary in usefulness for predicting whether faculty include computation in their courses. We will present the least and most predictive personal, attitudinal, and departmental factors.

### **BA09: 2:50-3:00 p.m. Instructor Approaches to Teaching Computational Physics Problems in Problem-based Courses**

*Contributed – Alanna Pawlak, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824; pawlakal@msu.edu*

*Paul W. Irving, Marcos D. Caballero, Michigan State University*

An increasing number of introductory physics courses are seeking to incorporate “authentic practices”, and one way they are doing this is by including computational problems. Computational problems offer students an opportunity to engage with the programming practices and numerical problem solving methods used by physicists. Understanding how instructors approach teaching such problems is important for improving instruction and problem design. We conducted a phenomenographic study using semi-structured interviews with instructors in a problem-based introductory mechanics course that incorporates several computational problems. The instructors we interviewed were undergraduate learning assistants, individuals who were previously successful as students in the course. Their prior involvement as students, along with their relatively fewer experiences with programming and physics compared to the faculty instructors, give them a unique perspective on teaching in the course. We present here the results of our analysis, which describe the experiences of learning assistants teaching computational problems in this course.

### **BA10: 3:00-3:10 p.m. Students' Experiences with Skills Progressions in EMP-Cubed**

*Contributed – Daryl J. McPadden, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824; mcpadden@msu.edu*

*Paul Hamerski, Marcos D. Caballero, Paul Irving, Michigan State University*

Projects and Practices in Physics (P-Cubed) is a two-semester sequence of introductory, calculus-based physics course that is designed to help students develop skills in problem solving, teamwork, computational modeling and reflective learning. The P-Cubed courses are flipped courses with online notes to be read before class each week, pre-/post-week homework assignments, and in-class problems designed from work in project-based learning. Every week, students complete two in-class projects (either analytical or computational) and receive individualized feedback from an instructor on their work that week. As the second semester on electricity and magnetism, EMP-Cubed is designed to build on the skills from the first semester mechanics course, with intentional progression in both computation and student feedback. In this talk, we present the students' reflections from the first iteration of EMP-Cubed on their development in computation and feedback.

### **BA11: 3:10-3:20 p.m. Comparing Active Learning Environments: SQLabs and EMP-Cubed**

*Contributed – Emily M. Smith, Cornell University, 142 Sciences Dr., Ithaca, NY 14850; emsmith@cornell.edu*

*Daryl McPadden, Paul W. Irving, Michigan State University*

*N. G. Holmes, Cornell University*

Structured Quantitative Inquiry Labs (SQLabs) and the Electricity and Magnetism Projects and Practices in Physics (EMP-Cubed) are research-based curricula that aim to engage students in authentic, collaborative scientific practices. SQLabs promote students' independent decision-making in experimentation by engaging students in iterative processes to improve measurements and compare data to models. EMP-Cubed emphasizes group collaboration and modeling (both analytical and computational) through problem-based-learning projects. Though the objectives of the courses differ in several ways (e.g., content and classroom setting), many underlying goals are shared, such as encouraging students' collaborative decision making and engagement in authentic scientific practice. In this talk, we compare and contrast the learning objectives and messaging that students receive within each instructional context through materials and instruction. The aim of decomposing features of active learning environments is to identify critical components that contribute to shared learning objectives across research-based curricula.

**BA12: 3:20-3:30 p.m. Driving Change in Physics through Multi-Disciplinary Science Programs**

Contributed – Jessica L. Rosenberg, George Mason University, 4400 University Drive, Fairfax, VA 22030-4444; jrosenb4@gmu.edu

Benjamin Dreyfus, George Mason University

George Mason University is a large public research university in Northern Virginia. The retention of physics majors is an ongoing challenge. The retention challenge is not limited to the Department of Physics and Astronomy, it is one felt across the sciences. To improve recruitment, retention, and workforce development while reducing the time to degree for undergraduate students, the STEM Accelerator was founded in 2011. The STEM Accelerator resides within the College of Science and includes faculty that split their time between a science department and the Accelerator to work towards achieving these goals. I will discuss the connections between the Accelerator and the Department of Physics and Astronomy. I will also discuss the impact of the key programs including the LA program, Math Readiness Camp, and STEM Boot Camp.

**Session BB: Using Historical and Popular Texts in Physics Teaching**

**Location:** Marriott Marquis - Chinatown Room **Sponsor:** Committee on Physics in Undergraduate Education **Co-Sponsor:** Committee on History and Philosophy in Physics

**Time:** 1:30–3:10 p.m. **Date:** Monday, July 30 **President:** Joseph Ribaud

**BB01: 1:30-2:00 p.m. Why “Old Physics” Still Matters: History as an Aid to Understanding**

Invited – Chad Orzel, Union College, 807 Union St., Schenectady, NY 12308; orzelc@union.edu

A common complaint about physics curricula is that too much emphasis is given to “old physics,” phenomena that have been understood for decades, and that curricula should spend less time on the history of physics in order to emphasize topics of more current interest. Drawing on experience both in the classroom and in writing books for a general audience, I will argue that discussing the historical development of the subject is an asset rather than an impediment. Historical presentation is particularly useful in the context of quantum mechanics and relativity, where it helps to ground the more exotic and counter-intuitive aspects of those theories in a concrete process of observation and discovery.

**BB02: 2:00-2:30 p.m. Linking Science Fiction with Physics Courses**

Invited – Krista McBride, Belmont University, 1900 Belmont Blvd., Nashville, TN 37212; krista.mcbride@belmont.edu

A learning community was created between two general education courses: a physics course entitled Intro to Physics and a literature course entitled Science Fiction, Science Fact. By combining science fiction with physics, students achieve a deeper understanding of the nature of physics and explore how science and the perception of science progresses over time. In analyzing the presentation of science and technology in both written texts and film, students use critical thinking skills to decide what is possible and what is impossible. Because hard science fiction and physics communicate a shared set of values and knowledge, this integrated learning enriches science instruction and engages learners. Further, it can reduce negativity towards science and connect fiction to reality while aiding students to grasp a clearer understanding of physics concepts and the evolution of scientific theories. Advantages and challenges in developing and evaluating shared assignments for such linked classes will be discussed.

**BB03: 2:30-2:40 p.m. Reading Aristotle, Newton, Hooke and Maxwell in Conceptual Physics**

Contributed – Scott Bonham, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101; Scott.Bonham@wku.edu

Over the last several years students in my general education physics course have read historical texts by Aristotle, Isaac Newton, Robert Hooke and James Clark Maxwell in which they present arguments for their understanding of the nature of light, color and vision. I use these texts to introduce course topics, expose students to the history and philosophy of science, and develop scientific argumentation skills. As most of my students have never read texts like these, they are provided with support to read and understand the texts, in the form of reading guides, pre-class (warmup) questions, and in-class discussions. I also connect most of readings with in-class activities that replicate or build on observations described in the reading. In this talk I will discuss the readings I use, how they are integrated into the course, and some of the student responses.

**BB04: 2:40-2:50 p.m. Introductory Mechanics for Physics Majors: A Historical Approach**

Contributed – Katemari D. Rosa, Federal University of Bahia, Instituto de Física - UFBA, Campus Universitário de Ondina, Rua Barão de Jeremoabo, s/n, Salvador, BA, BA 40170-115 Brazil katemari@gmail.com

In this presentation, I will share my experience developing and teaching an introductory mechanics course for first-year physics undergraduate students. This course is part of a curriculum reform in Physics at the Federal University of Bahia, in Brazil. Concepts of Physics A focuses on Mechanics and brings, among other things, discussions on Cosmology, Aristotle’s physics, Ptolemaic Astronomy, the Copernican Revolution, Kepler, Galileo and the born of Newtonian physics. One of the challenges faced was the lack of historical approach in traditional textbooks. Historical texts such as Copernicus’ Coriolanus, Descartes’ Discourse, Galileo’s Dialogue and Newton’s Principia were used in class as well as other materials. In addition, an experimental component was added, through a reconstruction of or “a new take on” historical experiments, such as using a gnomon, replicating Eratosthenes experiment or building Galileo’s inclined plane.

**BB05: 2:50-3:00 p.m. Writing, Reasoning, and Problem Solving with Primary Historical Sources**

Contributed – David L. Morgan, Richard Bland College, Richard Bland College, 11301 Johnson Rd., Petersburg, VA 23805; dmorgan@rbc.edu

Primary historical sources are of use in the physics classroom both as a way to present the development of physics in its historical context, and as a way to gauge students’ conceptual understanding of physics ideas through writing and reasoning activities. They can also be an interesting and instructive source of physics problems that provide a departure from the traditional end-of-chapter textbook problems. This talk will present examples from the writings of Aristotle, Descartes, Huygens, Newton, Count Rumford, and others that are appropriate for introductory physics students at a variety of levels.

**BB06: 3:00-3:10 p.m. The Hindenburg Disaster: Combining Physics and History in the Laboratory**

Contributed – Gregory A. DiLisi, John Carroll University, 1 John Carroll Blvd., University Hts., OH 44118; gdilisi@jcu.edu

On May 6, 1937, the German passenger zeppelin Hindenburg, hovering 300 feet in the air and held aloft by seven million cubic feet of hydrogen gas, burst into flames while preparing to dock at the Naval Air Station in Lakehurst, NJ. Amazingly, the ensuing fire consumed the massive airship in only 35 seconds! In the aftermath, 35

of 97 people onboard died (13 passengers and 22 crewmen) plus one member of the ground crew. We present the Hindenburg disaster as a case study in the flammability of fabrics. Our goal is to examine the ship's outer covering and decide whether or not it was the fire's initial source of fuel. To accomplish this, we piloted a basic vertical flame test with students in an introductory-level undergraduate laboratory. The case study provides several unique teaching opportunities.

## Session BC: Exchange of Ideas and Faculty in International Teacher Preparation: Lessons Learned

**Location:** Marriott Marquis - Magnolia    **Sponsor:** Committee on International Physics Education    **Co-Sponsor:** Committee on Teacher Preparation

**Time:** 1:30–3:10 p.m.    **Date:** Monday, July 30    **President:** Dan Maclsaac

### BC01: 1:30-2:00 p.m. Re-envisioning Canadian Physics Teacher Education through Indigenous Knowledge and Star-lore

*Invited – Richard P. Hechter, University of Manitoba, Faculty of Education, Department of CTL, Office 227B, Winnipeg, MB R3T2N2 Canada; richard.hechter@umanitoba.ca*

Within Canada, where teacher certification is under the jurisdiction of each province, there has been a call for incorporating Indigenous knowledges within teacher education programs. Specifically, from exploring Indigenous ways of knowing, to the storytelling of Indigenous star-lore from local and global communities, our physics teacher education courses have been revised to increase students' physics education resonance on personal, community, and global levels. Physics teacher education in Canada is now being taught and learned through multiple perspectives, with a special dedication to expanding our physics pedagogical approaches beyond traditional standards through a dedicated inclusion of global perspectives in physics. This presentation will highlight insights emerging from this change in philosophical design of physics teacher development. Through the context of sharing Indigenous star-lore stories, this session will also share the lessons learned, and impact of, including Indigenous physics knowledge found within Canada and globally in to physics teacher education.

### BC02: 2:00-2:30 p.m. Physics Teacher Preparation and Initiatives at Universitaet zu Koeln

*Invited – Andre Bresges, University of Cologne, Gronewaldstraße 2, Cologne, NRW 50931 Germany; andre.bresges@uni-koeln.de*

*Kathleen A. Falconer, Daniel Maclsaac, University of Cologne*

We describe physics teacher preparation at Universitaet zu Koeln including an overview of demographics, graduating numbers and programs. In Germany there has been recent major reformation of physics teacher preparation to better integrate theoretical and practical experiences. To address these changes and the need for new styles of teaching and learning, a number of methods and practices have been modified, created and tested in a cooperation of German and International researchers, including the use of Action and Design Based Research (TADBARC) in teacher master's dissertations in local and international contexts; a greatly expanded use of digital media in future preparation (ZuS); and the development of a network of STEM school labs (schuelerlabor) that also assists to identify and recruit grade school students to the profession of STEM teaching.

### BC03: 2:30-2:40 p.m. Physics Educator Certification in the United States and the Netherlands

*Contributed – Erin R. Fosnocht, Virginia Tech, 324 Miller Rd., Waynesboro, VA 22980; erin98@vt.edu*

This paper provides historical overviews of physics education and reform in the United States and the Netherlands. Special emphasis is given to teacher-driven reform movements and their impact on physics curricula. In general, teacher-driven reform emphasizes the interaction between physics and society as a framework for teaching various concepts in physics. Next, certification and training requirements for secondary physics educators in the two countries are examined, compared, and contrasted. Specifically, requirements for teachers in Utah and Virginia and requirements for Dual Enrollment and Advanced Placement teachers are evaluated. This paper concludes by exploring connections between the effectiveness of these reform movements and the education, training, and certification of teachers in each country.

### BC04: 2:40-2:50 p.m. Physics Teacher Education in England: Then, Now and the Future

*Contributed – James de Winter, University of Uppsala - Physics Education Research Group, Department of Physics and Astronomy, Physics Education Research, Uppsala, SE-751 20 Sweden; james.dewinter@physics.uu.se*

*John Airey, University of Uppsala - Physics Education Research Group*

The recruitment and retention of high quality physics teachers in England has been and remains a challenge. National publicity campaigns, intervention from the Institute of Physics and tax-free bursaries (up to \$35,000 tax free) seem to have little effect on the number of graduates entering the profession. In this session I will focus on the nature and content of the teacher preparation course at the University of Cambridge as well as reflecting on the wider landscape of teacher education in England, the factors that shape it and how this may develop into the future. I will also share findings from recent research on views from a stakeholder survey across the education community exploring perceptions of the attributes of the 'good' physics teacher that seems in such short supply.

### BC05: 2:50-3:00 p.m. Group Activities Developed in the Schwartz/Reisman Science Education Center

*Contributed – Netanel Hazut, Schwartz/Reisman science education center, Max nordau 21, Rehovot, Israel 7624206 Israel netanel.hazut@weizmann.ac.il*

*Nir Peer, Avishai Amar, Schwartz/Reisman science education center*

The Schwartz/Reisman science education center was established in September 2013 as a Campus within the perimeters of the Weizmann Institute of Science, Israel. The center's vision and strategy are based on three key concepts: highly trained teachers, cutting-edge laboratory facilities, and a growing community of science teachers working together. These are features that most schools can't offer. In our presentation we will share activities performed in our classrooms, which are a result of the teamwork of teachers. These are project-oriented activities, in which the students work in groups and try accomplish tasks given by the teacher, where the goal is to successfully perform a physical experiment. For example, the calculation of the ballistic motion of a ball shot from a cannon. Each group needs to place a metal ring at deferent locations in the correct height. These activities aid in the learning process, are fun and increase the students' self-efficacy.

### BC06: 3:00-3:10 p.m. Lesson Study Improves College Physics Teaching in USA and Japan

*Contributed – Sachiko Tosa, Niigata University, 8050 banchi, 2-no-cho, Nishi-ku Niigata, Niigata 950-2181 Japan stosa@ed.niigata-u.ac.jp*

This study examines how Lesson Study can help both students and faculty in introductory physics courses in U.S. and Japanese colleges. Lesson Study is a collaborative lesson planning and discussion model for teachers. A Lesson Study cycle consists of three phases: lesson planning, teaching/observing, and debriefing. In Lesson

Study conducted at the college level, discussion in the planning session focuses on the content in physics as well as active-learning instructional strategies, such as the use of clickers and white boards in group discussions. Student achievement was measured by administering pre/post-test of FCI. The results indicate a stronger impact of the physics courses in an active learning style than the courses in a traditional teaching style in both countries. The results also indicate that Lesson Study helped faculty see teaching in a more student-centered way.

## Session BD: Get Started! Integrating Computation into Courses at Any Level

**Location:** Congressional Ballroom A    **Sponsor:** Committee on Space Science and Astronomy    **Co-Sponsor:** Committee on Educational Technologies  
**Time:** 1:30–3:30 p.m.    **Date:** Monday, July 30    **Presenter:** Ernest Behringer

### BD01: 1:30-3:30 p.m. Enhancing Conceptual Understanding and Building Problem-Solving Skills through Computation

*Invited – Michelle Kuchera, Davidson College, Box 7133, Davidson, NC 28035; mikuchera@davidson.edu*

Computation in the classroom can be used to enhance understanding of physics concepts as well as provide students with skills related to problem solving in research and industry applications. I will discuss how my computational exercises differ in physics courses at various levels. In-class “workshop-style” exercises using the pair programming paradigm, which is borrowed from computer science pedagogy, will be demonstrated. Examples of integrating exercises in the laboratory and classroom will be discussed, along with commentary on how I fit computational learning goals into the existing curriculum. I will frame this talk within the context of using the python programming language, along with Jupyter notebooks, in classes of less than 30 students at Davidson College.

### BD02: 1:30-3:30 p.m. Gaining Consensus within the Department Around Computation

*Invited – Steven Wolf, East Carolina University, 1000 E. 10th St., Howell Science Building, Greenville, NC 27858-4353; wolfs15@ecu.edu*

Over the past two years, I have been implementing computational exercises in my calc-based introductory physics courses. As is the case at most universities, East Carolina University has many sections of intro physics taught by multiple instructors. So in order for computational exercises to become as standard part of intro physics courses, multiple stakeholders need to buy-in to the process. I will be discussing my experiences with this departmental discussion in-progress, as well as my successes and lessons learned from this discussion.

### BD03: 1:30-3:30 p.m. Python from the Start: Experiences with Villanova and LIGO

*Invited – Amber Stuver, Villanova University, 800 E Lancaster Ave., Villanova, PA 19085; amber.stuver@villanova.edu*

Currently, little physics/astronomy research is done with pencil and paper alone; today, computational tools to analyze, model, and visualize data are the tools of choice. While students regularly use powerful computational tools (Wolfram Alpha, Excel, etc.), many don't know how to create their own computer algorithms tailored to their specific needs. To address this, physics/astronomy majors at Villanova University are formally introduced to Python and supporting tools in the first freshman semester and I am redeveloping this curriculum to improve students' literacy in Python. These skills are expected to be applied immediately in introductory labs, extensively in advanced labs, while Jupyter notebooks are being used in other physics courses to illustrate the behavior of the theory being learned. I will also share my use of Python with undergraduate students for gravitational wave research and how the LIGO Scientific Collaboration uses tools like Jupyter to make gravitational-wave data accessible to the public.

### BD04: 1:30-3:30 p.m. Integrating Computation into Courses from General Education to Intermediate Physics

*Invited – Aaron P. Titus, High Point University 1 University Pkwy High Point, NC 27268-0002; atitus@highpoint.edu*

I first integrated computation into my calculus-based physics course in 2003 through the “Matter & Interactions” textbook by Chabay and Sherwood. This eventually led to a physics degree program launched in 2010 in which every course for physics majors includes computation. Now, two of our general education physics courses include computation. We have learned the following lessons: (1) provide explicit instruction in computation during lab or class (i.e. computing should not be relegated to homework); (2) in introductory classes, reduce technical barriers associated with software installation; (3) transform what you teach to include iterative thinking. I will present these lessons and show examples of computing across the curriculum.

### BD05: 1:30-3:30 p.m. Programming Modules for Algebra-based Electromagnetism: Using Coding to Enforce Physics Concepts\*

*Poster – Richelle M. Teeling-Smith, The University of Mount Union, 1972 Clark Ave., Alliance, OH 44601; teelinri@mountunion.edu*

*Chris Orban, Chris Porter, The Ohio State University*

We present a series of electromagnetism programming modules that can be easily integrated into an algebra-based introductory physics course. These modules are game-like, browser-based (requiring no software installations), and are designed to highlight the physics aspects of an interactive simulation code while obscuring other details, making them ideal for beginner programmers. We will describe the effort to probe the impact of these coding activities on student conceptual learning using a series of animated questions inspired by the Brief Electricity and Magnetism Assessment. These activities and assessments are currently being used in introductory physics classes at Mount Union and OSU Marion, as well as in a number of high school physics classrooms across Ohio.

\*The STEMcoding Project is supported by the AIP Meggers Award and internal funding from OSU.

### BD06: 1:30-3:30 p.m. STEMcoding Project: Bringing the Hour of Code to the Physics Classroom\*

*Poster – Chris Orban, Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; orban@physics.osu.edu*

*Richelle Teeling-Smith, University of Mount Union*

Despite the success of code.org and the hour of code(TM), very little content currently exists to integrate coding into introductory STEM courses even though computer science is now designated as a “core subject”. In fall 2017, the STEMcoding project released an hour of code activity (go.osu.edu/hourofcode) on the physics of video games and started a youtube channel (go.osu.edu/STEMtube). Importantly, a high percentage of the people featured in the videos come from underrepresented groups in STEM, and we try to ensure that it is mostly undergrads on screen, rather than professors or post-docs. This poster provides an overview of the coding resources that are freely available, summer training opportunities for teachers and future plans.

\*The STEMcoding Project is supported by the AIP Meggers Award and internal funding from OSU.

**BD07: 1:30-3:30 p.m. Use of Computation in Upper Level Mechanics at Winona State**

Poster – Sarah R. Phan-Budd, Winona State University, 175 West Mark St., Winona, MN 55987-0838; sphanbudd@winona.edu

The physics department at Winona State has been expanding the use of computation across the physics curriculum. This poster will focus on the upper-level mechanics course which has recently been refreshed to include a computational portion implemented using Jupyter notebooks. We will discuss updated computational activities used both during class time and as homework assignments. We will also discuss how the physics department and other faculty members in the college of science and engineering have been training and supporting their fellow instructors to enable them to include more computation in their courses.

**BD08: 1:30-3:30 p.m. Challenges in Creating Accessible Materials for Online Physics Courses**

Poster – Yuri B. Piedrahita, Purdue University, 100 N. University St., West Lafayette, IN 47906; ypiedrah@purdue.edu

Carina M. Rebello, N. Sanjay Rebello, Purdue University

Nowadays there is an increasing presence of online courses in all fields of science, and particularly physics. Making such courses accessible to individuals with visual or auditory difficulties is imperative. Therefore, transforming common class materials from face-to-face classes (e.g., PowerPoint slides, or Word documents) to accessible materials is one of the first tasks towards designing an effective accessible online course. Although current reading programs have achieved relevant advances in accessibility, they still present a variety of limitations. For example, the inability of such reading programs to differentiate between say vertical lines in text, which in math represent the absolute value, but in physics might also represent the magnitude of a vector quantity. We spotlight the challenges found during the process of making the class materials of a Modern Mechanics course accessible, offering potential solutions with the aim to support others undertaking similar efforts.

**BD09: 1:30-3:30 p.m. Engaging Physics Students with Computation and Visualization**

Poster – Jay J. Wang, UMass Dartmouth, 285 Old Westport Rd., North Dartmouth, MA 02747-2300; jwang@umassd.edu

In this presentation we discuss integration of computation and visualization into the physics curriculum to actively engage student's learning. We will focus on sophomore and higher level classes where numerical computation is an integral component of the coursework. For example, introductory quantum mechanics is arguably the place where students benefit the most from computation only a handful of problems could be solved exactly in closed-form solutions, and virtually no time-dependent problem is accessible without computer simulation. Yet important concepts such as time-evolution of coherent states and tunneling are difficult to visualize and grasp to beginners of quantum mechanics. We describe activities that emphasize both computation and visualization within the Jupyter Python environment. We also describe creating an interactive computing and visualization environment with IPython widgets to make the activities more effective (see <http://www.faculty.umassd.edu/j.wang/> for sample activities).

**BD10: 1:30-3:30 p.m. Initiating Computation in the Introductory Lab**

Poster – Andrew D. Gavrin, Department of Physics, IUPUI, 402 N. Blackford St., LD154, Indianapolis, IN 46202; agavrin@iupui.edu

As part of a department-wide effort to introduce computational methods across the curriculum, I have begun to develop and implement computational experiences for the labs in our introductory course sequence. The first computational experiences students see are based on PhET simulations.\* They use these to get a sense of what it means to do an "experiment" on a system someone else has already modelled. In later exercises, they use excel to develop their own models. To date, I have developed and classroom tested two PhET based experiments (both in mechanics) and two excel-based projects (one each in mechanics and E&M).

\*<https://phet.colorado.edu/>

**BD11: 1:30-3:30 p.m. Integrating Computation into Introductory and Intermediate Optics**

Poster – Ernest Robert Behringer, Eastern Michigan University, Department of Physics and Astronomy, Ypsilanti, MI 48197; United States ebehringe@emich.edu

Optics provides many opportunities for integrating computation into the physics curriculum. Several computational activities, touching on geometric and physical optics, will be presented that can help students learn and apply optical concepts while achieving many of the learning outcomes described in the AAPT recommendations for the laboratory curriculum and for computational physics. While completing these activities, students use spreadsheets and structured language programs to generate and represent numerical data, to represent experimental data, to compare the predictions of theoretical models to experimental results, and to use models to predict outcomes in new situations. A subset of these activities, covering shadows, rainbows, and laser beam profiles, are available at the Compadre website for the Partnership for Integration of Computation into Undergraduate Physics.

**BD12: 1:30-3:30 p.m. Integrating Computation into Thermodynamics and Statistical Mechanics**

Poster – Marie Lopez del Puerto, University of St. Thomas, 2115 Summit Ave., Saint Paul, MN 55105; mlpuerto@stthomas.edu

Computation and statistical mechanics go hand in hand. I have integrated several short computational (and even some experimental!) projects into an upper-level Thermodynamics and Statistical Mechanics course at the University of St. Thomas. While relatively easy to code, these projects help illustrate and clarify fundamental ideas (equilibrium, multiplicity, probability distributions, etc). Several example projects are presented in this poster.

**BD13: 1:30-3:30 p.m. Jupyter Notebook: A Natural Fit for Integrating Computation into Many Courses**

Poster – Steve Spicklemire, University of Indianapolis, 1400 E Hanna Ave., Indianapolis, IN 46227; spicklemire@uindy.edu

From "Scientific Computing" and "Intro Electronics" to "Quantum Mechanics" and "Advanced Lab" the "Jupyter Notebook" provides a flexible foundation for integrating computation into a variety of classes. Some of the relevant features of Jupyter Notebooks will be highlighted and a diverse set of examples provided.

## Session BE: Panel – High School Teachers Doing Action Research

Location: Marriott Marquis - Dogwood Sponsor: Committee on Physics in High Schools Time: 1:30–3:30 p.m. Date: Monday, July 30 President: Michael Lerner

### BE01: 1:30-3:30 p.m. Action Research on Facilitating Classroom Discourse

Panel – Scot Hovan, St. Paul Academy, 1712 Randolph Ave., St. Paul, MN 55105-2194; scothovan@gmail.com

Classroom discourse is a fundamental aspect of teaching and learning, but rarely do teacher preparation programs train educators how to facilitate this discourse. Thoughtful action research can result in meaningful growth of an instructor's awareness of and expertise in facilitating classroom discourse. In this presentation I will discuss possible action research questions that range in commitment from minutes to months but whose results will inform instruction and enhance understanding of communication patterns present in the classroom.

### BE02: 1:30-3:30 p.m. Action Research: Using Problems of Practice to Inform Instruction

Panel – Nicole B. Schrode, St. Vrain Valley School District and University of Colorado, 227 Sunland St., Louisville, CO 80027-1237; schrode\_nicole@svvsd.org

Is my curriculum reaching my lower third? Are ELLs making learning gains? Do my students really understand what counts as evidence in a CER? These are some examples of the questions I grapple with regularly in my classroom. I will share how I have turned these problems of practice into action research studies. Best practices for collecting and analyzing student data and how I used the data to inform instruction or curriculum will also be presented. I will also discuss how to share findings with stakeholders within your school, district, or teachers nationwide.

### BE03: 1:30-3:30 p.m. Role Reversal: What We Learn From Our Physics Students

Panel – Danielle Bugge, Rutgers University, 8 Perrine Path, West Windsor, NJ 08550; danielle.bugge@rutgers.edu

Eugenia Etkina, Rutgers University

Science practices are an integral part of learning physics. Recommendations of the Next Generation Science Standards (NGSS) and Advanced Placement Physics 1 and 2 guidelines call for incorporating these practices into learning and instruction. How do we know whether students achieve proficiency on the standards set by NGSS and College Board? The goal of this talk is to share my experiences conducting action research in a first-year physics classroom. In my classroom, students learn physics through the Investigative Science Learning Environment (ISLE) method. They regularly design their own experiments that engage them in the science practices and focus on the development of their scientific abilities. Students share their findings through white board symposia and written reports. We report on the study in which we collect and analyze student descriptions of designed experiments and their reflections in order to answer questions related to the development of science practices for young learners.

### BE04: 1:30-3:30 p.m. PLC-Embedded Action Research

Panel – Marta R. Stoeckel, Tartan High School, 828 Greenway Ave. N, Oakdale, MN 55128; mstoeckel@isd622.org

Action research has become a core part of professional learning communities (PLCs) in North St. Paul-Maplewood-Oakdale Public Schools, with an emphasis on small-scale projects. Instructional coaches and district leaders have developed a structure to support PLCs in engaging in worthwhile action research, even when PLC members have minimal background and experience. I will discuss projects completed by the physics PLC, including a year-long examination of student self-assessments on unit quizzes and single-lesson interventions to improve student performance on experimental design problems based on the AP Physics 1 exam.

## Session BF: Innovations in Teaching Astronomy

Location: Marriott Marquis - Scarlet Oak Sponsor: Committee on Space Science and Astronomy Time: 1:30–3:30 p.m. Date: Monday, July 30 President: Kristi Concannon

### BF01: 1:30-2:00 p.m. Innovating Astronomy Education with Robotic Telescopes

Invited – Kathryn Elizabeth Williamson, West Virginia University, 135 Willey St., White Hall Room 111, Morgantown, WV 26506-0002; kewilliamson@mail.wvu.edu

We are on the cusp on an astronomy education revolution. Robotic telescopes are now bringing the excitement of authentic astronomy practices and concepts to large numbers of students and educators far and wide. With internet access to a world-wide network of remotely-controlled, research-quality telescopes, even the most novice student can obtain accurate position measurements of asteroids, collect and analyze images of planetary systems to test Kepler's laws, and map the invisible universe through radio astronomy. In this talk, I will provide an overview of the Skynet Robotic Telescope Network and the diverse ways educators across the country have used it to engage students of all ages and in a variety of settings. To provide an example, I will describe how I have used the Green Bank 20-meter radio telescope to adapt a common "Mapping the Milky Way" project to the general education, large-enrollment, lecture-based, college astronomy course.

### BF02: 2:00-2:30 p.m. Astronomy Education: Where Have We Been? Where Are We Going?

Invited – Colin S. Wallace, University of North Carolina at Chapel Hill, Dept. of Physics and Astronomy, 120 E Cameron Ave., Chapel Hill, NC 27599-0001; cswphys@email.unc.edu

Astronomy education research (AER) is a unique discipline. Its practitioners are often found in physics departments, and many have backgrounds in PER. However, unlike PER, which traditionally focuses on STEM majors, AER has primarily focused on students in general education, introductory astronomy (Astro 101), many of whom are taking their final science course in life. In this talk, I will describe how AER fits in the national landscape of discipline-based education research. I will highlight some of the major findings and accomplishments of AER in order to elucidate challenges the discipline faces as well as opportunities for advancing our understanding of the teaching and learning of astronomy. I will present my perspective on what the frontier of AER looks like and where the discipline should go in the future.



**BF03: 2:30-2:40 p.m. The Dakota State University (DSU) STEM Institute Summer Program**

*Contributed – James A. Maloney, Dakota State University, 820 North Washington Ave., Madison, SD 57042-1799; james.maloney@dsu.edu*

Studies show that the greatest attrition in STEM majors moving to non-STEM programs occurs during their first year. To promote recruitment, retention, and student success, DSU conducted summer STEM Institutes in 2014 and 2016. The eclectic variety of STEM topics in past programs was not fully integrated. A new curriculum was designed around the popular themes of astronomy, rocketry, and space science. These themes offer appeal across the wide range of students' interests, particularly the large number of students enrolled or interested in DSU's computer science and cyber technology programs. Daily seminars, demonstrations and hands-on experiments cover concepts essential to understanding rocketry and incorporates aspects of astronomy and space science to help build interest and excitement among all participants. Past programs and lessons learned will be reviewed, and well as the motivation and implementation of the new integrated curricula. A K-12 outreach program implementing similar curricula will be presented.

**BF04: 2:40-2:50 p.m. Implementing a Horn Radio Telescope in HS Physics and Astronomy**

*Contributed – John L. Makous, Providence Day School, 5800 Sardis Rd., Charlotte, NC 28270; john.makous@providenceday.org*

The results of our experience in the Research Experience for Teachers - Digital Signal Processing In Radio Astronomy program at West Virginia University will be presented. Specifically we will discuss the construction of the horn structure, analog electronics assembly, and digital design using software defined radio. We further discuss the operation, and use of a horn radio telescope in high school physics and astronomy courses. This telescope is designed to detect the 21 cm wavelength emitted by atomic hydrogen, enabling students to map hydrogen in the Milky Way Galaxy, as well as determine detailed information about its structure.

**BF05: 2:50-3:00 p.m. Teaching Hands-On Observational Astronomy to a Wide Range of Students**

*Contributed – Donald Andrew Smith, Guilford College, 5800 W. Friendly Ave., Greensboro, NC 27410; dsmith4@guilford.edu*

I will present the design of a hands-on course to use telescopes to observe and photograph the night sky. The two main challenges of the course are the weather and the diverse backgrounds of the students. Students are typically a mix of physics majors and non-science students fulfilling a breadth requirement. The course uses a flipped classroom approach to help all students learn the basics of coordinate systems, optics, and time measurements. Then students choose 10 labs that match their skills and interests. The last month of the course is spent on an individual project that they develop themselves. I will report on the strengths and weaknesses of the flipped classroom approach and give examples of how the labs balance archival data analysis with rooftop observing to give students the ability to be flexible around the weather. Finally, I will share examples of some of the projects students have developed.

**BF06: 3:00-3:10 p.m. Going Paperless: Integrating Google Docs, Drive and Classroom into an Astronomy Lab Program**

*Contributed – David C. McCallister, University of Tennessee, Knoxville, 401 Nielsen Physics Building 1408 Circle Drive, Knoxville, TN 37996-1200; davey.mccallister@gmail.com*

Google Classroom is a free service for schools to “go paperless” with digital creation, submission, and grading of work. This presentation will provide examples of how traditional lab activities were easily modified to enhance the effectiveness of the lab exercise, such as crowd-sourced data collection for the entire section/course. Specific examples include generating an HR diagram and semester-long lunar observations. Going paperless has also streamlined grading for the lab instructors, and allowed students to give feedback to the instructor. Future plans are to expand to other lab activities and to compose new lab activities leveraging Google Forms for reporting data to a central database.

**BF07: 3:10-3:20 p.m. Exploring Mars with LEGO Mindstorm Robotics: A FYF College Course**

*Contributed – Debbie A. French, Wilkes University, 84 W. South St., Wilkes-Barre, PA 18766; frenchd14@yahoo.com*

All incoming freshmen and students new to Wilkes University must take a First Year Foundations (FYF) course. Faculty may develop an FYF course in any field of interest. FYF courses balance content with lessons on navigating the college experience. In this presentation, I will describe a Mars-themed FYF course where students completed LEGO Mindstorm Robotics Space Exploration missions. Students also learned about astronomy, integrated STEM concepts, and introductory programming (along with some required FYF elements). Student learning outcomes, student feedback, STEM connections, lessons learned, and next steps will be shared.

**BF08: 3:20-3:30 p.m. Using Motion Sensor Devices and VR Headsets in the Planetarium**

*Contributed – Pamela A. Maher, University of Nevada, Las Vegas, 718 Lacy Lane, Las Vegas, NV 89107-4440; maherp@unlv.nevada.edu*

*Janelle M. Bailey, Temple University*

*P.G. Schrader, University of Nevada Las Vegas*

For decades, planetaria have been used for teaching and learning by simulating the celestial sphere. A planetarium can supplement observation by conventional methods that use the electromagnetic spectrum to gather information about the heavens. This study describes how planetaria applications can be extended by using other simulation tools. The focus is on two tools that are of interest to practitioners: motion sensor devices (MSD), used with the full-dome planetarium, and virtual reality (VR) headsets. Data were collected from  $N = 67$  introductory college astronomy students in a study to investigate the variety of experiences they had when using each device to manipulate a lunar flyby in the college planetarium. Results show what each tool affords, things afforded by both tools (crossover affordances), and each tool's constraints as an aid for instructors, designers, and researchers in choosing a tool for their research or educational purposes.

**Session BG: Introductory Courses**

**Location:** Marriott Marquis - Silver Linden **Sponsor:** AAPT **Time:** 1:30–3:30 p.m. **Date:** Monday, July 30 **President:** Deborah Roudebush

**BG01: 1:30-1:40 p.m. A General Education Science Course**

*Contributed – Stephen C. Parker, Saint Martin's University, 5000 Abbey Way SE, Lacey, WA 98503; sparker@stmartin.edu*

*Darrell Born, Saint Martin's University*

At Saint Martin's University, we are in the process of revamping our general education curriculum and planning a new “core curriculum” of required courses that better reflects our Benedictine heritage. One of the required classes will be a natural sciences class with a laboratory component, but with the added feature that it will also need to have an interdisciplinary aspect associated with it. To this end, we have developed a course entitled “The Physics of Music,” where the class is co-taught by both a music professor and a physics professor. We taught a test run of this class two years ago, and we plan to offer this course on a more regular basis once the

new core has been fully implemented. I will talk about some of the lessons learned during our first experience with this class and comment on the interdisciplinary discussions that occurred in the course.

### **BG02: 1:40-1:50 p.m. Incorporating a Project-based Approach into Introductory Physics**

*Contributed – Paul J. Walter, St. Edward's University School of Natural Sciences, 3001 S. Congress Ave., Austin, TX 78704; pauljw@stedwards.edu*

We are in our second year of employing a team-based and project-based to calculus-based introductory physics based upon Eric Mazur and Kelly Miller's AP-50 course at Harvard University. Each month-long project culminates with a project fair with outside faculty serving as judges. We discuss the overall approach and the modifications that we have made while serving a different population at a Hispanic-serving institution. This talk will serve as a how-to and discuss resources that are available.

### **BG03: 1:50-2:00 p.m. Scale-Up/Traditional Format – A Detailed Comparison of Student Performance**

*Contributed – Andrew S. Hirsch, Purdue University, 525 Northwestern Ave., West Lafayette, IN 47907-2036; hirsch@purdue.edu*

*Chantal Leveque-Bristol, Taylor Brodner, Mark Haugan, Jennifer D. Moss, Purdue University*

We have compared exam performance between two equivalent populations of students taking introductory mechanics at Purdue University over two semesters. One population was exposed to the traditional lecture-recitation-lab format, while the other to a Scale-Up format. Both groups took four identical exams, three midterms and a final, and in addition completed the same pre-instruction and post-instruction knowledge exam. We will present the analysis of the performance of the two populations after grouping students according to comparable demographic characteristics.

1 Department of Physics and Astronomy, Purdue University, W. Lafayette, IN 47907 2Center for Instructional Excellence, Purdue University, W. Lafayette, IN 47907 3 Office of Institutional Research, Assessment and Effectiveness, Purdue University, W. Lafayette, IN 47907 4 <http://scaleup.ncsu.edu>

### **BG04: 2:00-2:10 p.m. Physics Instruction: Between Lev Landau and Eric Mazur**

*Contributed – David Pundak, Kinneret College, Kibbutz Ashdot Yaacov Ichud, Jordan Valley Israel, Israel 15155 Israel; dpundak@gmail.com*

*Miri Shacham, Ort Braude College*

Even though the physics instruction revolution regarding the active learning is about 30 years old, the debate with the traditional approach still exists. Prof. Lev Landau made fundamental contributions to many areas of theoretical physics, is a typical representative leader of mathematical deductive approaches. Landau requires accepting, as a first step, an abstract formula or statement dictate by the instructor without doubts and concentrate attention on the study of mathematical procedures. Prof. Mazur is leading opposite approach that concentrated on the students' difficulties to absorb the reality and to create scientific concepts. He pays attention to the students' ideas and how to represent physical systems by dynamic figures and appropriate mathematics. Following this debate, we study an introductory physics course lead by two instructors hold those different points of view. We evaluate the students' difficulties and achievements during the course and in the final exams. At our talk, we will discuss the study and its results.

### **BG05: 2:10-2:20 p.m. Calculus-based vs. Algebra-based Physics: How to Distinguish and Teach?**

*Contributed – Sajalendu Dey, Lindenwood University, St. Charles, MO 63301, 63 Arbor Hollow Court, Ellisville, MO 63011; SDey@Lindenwood.Edu*

*John Barr, Lindenwood University, St. Charles, MO*

In the universities in North America, at the undergraduate level, the introductory course in physics comes essentially in two different categories: the calculus-based physics and the algebra-based physics. But what makes these two categories of Introductory Physics different from each other? Understanding the answer to this question is certainly important not only for the teacher who teaches these courses, but also for the students who take these courses. Are there really any distinction? How much is the distinction if there are any? In this report, the authors have presented their own teaching experience to answer this question, and have tried to use an attribute-entity format to categorize the physics topics for better understanding of this calculus-algebra distinction.

### **BG06: 2:20-2:30 p.m. Using Math in Introductory Physics: They're Measurements, Not Numbers!\***

*Contributed – Edward F. Redish, University of Maryland, Department of Physics, College Park, MD 20742-4111; redish@umd.edu*

*Mark Eichenlaub, Deborah Hemingway, University of Maryland*

Many students run into trouble using math in introductory physics, despite having done well in prerequisite math classes. Many tend to see math as for doing calculations instead of as a way to organize and think about the physical knowledge we have about relationships among variables and parameters. Most of the symbols we use don't stand for numbers, but for physical quantities often generated through measurement. This motivates many tools we expect students to learn to use, including the closely interrelated topics of significant figures, units, dimensional analysis, and estimation. Many students resist this ontological shift, failing to see the value of the new and more complex perspective of "math with physical meaning." We show some of the tools (epistemic games) we have developed to help students make the transition to reasoning with math instead of just calculating with math.

\* Supported in part by NSF grant DUE-15-04366

### **BG07: 2:30-2:40 p.m. Electrical Analysis of Wheels and Stars**

*Contributed – Mikhail Kagan, Penn State Abington, 1600 Woodland Rd., Abington, PA 19001-3918; mak411@psu.edu*

*Brian Mata, Penn State*

Playing with electric circuits of interesting structure can make very engaging classroom activities and lead to thorough learning of multiple concepts across different disciplines. We investigate rotationally symmetric electric circuits of arbitrary size. Using the recently developed methods for computing equivalent resistance of generic electric networks, we obtain exact expressions for the equivalent resistance across arbitrary links of wheel- and star-like circuits. These expressions explicitly depend on the individual edge resistances, as well as on the circuit size  $N$  as an independent parameter. In some simple cases, students can see golden ratio and Fibonacci numbers show up in electrical circuits. The same analysis can be applied to computations of the complex impedance of AC-circuits of the same circular topology and allow students to investigate resonance phenomena therein. The obtained results have applications in graph theory (circulant graphs), matrix algebra and network security algorithms.

**BG08: 2:40-2:50 p.m. A Digital Text With Embedded Assessment**

Contributed – Michael J. Tammaro, University of Rhode Island, 2 Lippitt Rd., Kingston, RI 02881; tammaro@uri.edu

I will present an innovative, interactive online environment through which the student is actively engaged with the course content. The interactive pieces include concept questions, practice problems, interactive examples, videos, animations, click-to-open footnotes, and additional examples. The robust hints that accompany the assessment pieces, as well as the pop-up glosses, take the pedagogy to a new level, as the online environment is fully exploited in this first-of-its-kind product. With interactive questions embedded with the reading, and the usual compliment of assignable end-of-chapter problems, along with innovative tracking tools, the instructor has an excellent vantage point from which to track and evaluate student progress.

**BG09: 2:50-3:00 p.m. Adapting RealTime Physics for Distance Learning with IOLab-A Final Report**

Contributed – David R. Sokoloff, Department of Physics, University of Oregon, 1274 University of Oregon, Eugene, OR 97403-1274; sokoloff@uoregon.edu

Erik Bodegom, Portland State University

Erik Jensen, Chemeketa Community College

The IOLab is a versatile, relatively inexpensive data acquisition device developed by Mats Selen and his colleagues at University of Illinois (1). It is self-contained in a cart that can roll on its own wheels, and it includes an optical encoder that measures motion quantities and a force sensor. It also contains sensors to measure a variety of other physical quantities. With a current cost of around \$100, students can purchase their own individual device (like a clicker) and can-in theory-use it to do hands-on laboratory, pre-lecture (flipped classroom) and homework activities at home. We report on the results of a project (2) to develop distance-learning (DL) laboratories using the IOLab. We have adapted RealTime Physics Mechanics (3,4) labs for use with the IOLab and tested them in supervised laboratory environments and in distance learning mode at Portland State University and Chemeketa Community College. We will describe the labs and lab environments, and the significant FMCE (5) conceptual learning gains.

(1) See <http://www.iolab.science/> (2) Funded under U.S. National Science Foundation grant DUE - 1505086, July 1, 2015-June 30, 2017. (3) David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, "RealTime Physics: Active Learning Labs Transforming the Introductory Laboratory," Eur. J. of Phys.: 28 (2007), S83-S94. (4) David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, RealTime Physics: Active Learning Laboratories, Module 1: Mechanics, 3rd Edition (Hoboken, NJ, John Wiley and Sons, 2011). (5) Ronald K. Thornton and David R. Sokoloff, "Assessing student learning of Newton's laws: The Force and Motion Conceptual Evaluation and the Evaluation of Active Learning Laboratory and Lecture Curricula", Am. J. Phys.: 66, 338-352 (1998).

**BG10: 3:00-3:10 p.m. Investigating Reasons for Why Self-Paced Interactive Electronic Learning Tutorials Express a Challenge for Engaging Students**

Contributed – Edana M. Wilke, University of Cincinnati, 2600 Clifton Ave., Cincinnati, OH 45025; wilkea@mail.uc.edu

Alexandru Maries, University of Cincinnati

Zhongzhou Chen, University of Central Florida

While the use and availability of electronic self-paced learning tools has been growing in recent years, research suggests that many students do not engage with the learning tools as intended, resulting in less than desirable transfer of learning. A critical issue then remains how to design the implementation of electronic self-paced learning tools to encourage students to engage with them properly from them. We conducted an investigation in which students in an introductory physics course used self-paced, interactive, electronic learning tutorials as an extra aid in preparing for exams. The tutorials were designed around a challenging problem, similar to what students may encounter in an exam. The tutorial divided the problem into a series of subproblems which take the form of multiple-choice questions, with the goal of guiding students to use effective problem-solving strategies. We investigated a potential approach to motivate students to actively engage with the tutorials. Students were divided in two groups, one which was required to attempt the tutorial problem (by submitting an answer) before being allowed to move on to the guided subproblems (referred to as the RQ group). The other group, NRQ group, was given an option to skip the tutorial problem and move on to the guided subproblems. We found evidence students in the RQ group were slightly more likely to learn from the tutorial than the NRQ group, suggesting that requiring students to initially think about the problem may force them to be more active in the tutorial. We also discuss other possible interventions based on our study.

**BG11: 3:10-3:20 p.m. Acronyms**

Contributed – Shannon A. Schunicht, Mnemonic Writing, 4001 Stack Blvd., Cocoa Beach, FL 32931-3040; sschunicht@gmail.com

When taking any Physics class, be it Introductory PHY 201 or just high school math, further pursuit is steered away from due to the multitude of formulas required come test recollection. In 1985, this author was rendered unconscious "4" three weeks. Everything head "2b" relearned, only without a short term memory! When taking Physics, a pragmatic way of making acronyms from ANY FORMULA was devised, i.e. "a" for multiplication to imply "@", "o" for division to mean "over", "i" for subtraction to signify "minus", "u" for addition to symbolize "plus", and "e" for "equals". Most constants and variables are indeed consonants, e.g. "c" = "speed of light" & "z" = "altitude". ADDITION LETTERS may be inserted to enhance a letter combinations intelligibility, but need be CONSONANTS! I.e. The Quadratic Equation (exCePT i buiLD rabbiTS 4 caTS oN 2 HaTS). Everyone remembers Dr. Seuss? (Theodor Seuss Geisel) The possibilities of this mnemonic technique are limitless as ?X => 0! The possibilities of this mnemonic technique with Western languages are remarkable, whereas Eastern Characters have yet to "2b" explored!

**BG12: 3:20-3:30 p.m. Challenges and Opportunities of Gender and Major Subject Diversity in a 3-term Introductory Physics Sequence**

Contributed – Yuehai Yang, Oregon Institute of Technology, 3201 Campus Dr., Klamath Falls, OR 97601; yuehai.yang@oit.edu

Matthew Wilcox, University of Central Florida

Jackie Chini, University of Central Florida

Will the students who like their instructor learn better? A single 3-term sequence calculus-based introductory physics course for both bio-health science and engineering majors is offered in the four-year college. This unique setting of class present both challenges and opportunities for students from a diverse background to work together in and outside of the classroom. This presentation provides some insights into student interactions with each other and with their instructors, as well as the differences in their learning patterns, motivations and their success in the course.

## Session BH: PER: Assessment, Grading and Feedback

Location: Mount Vernon Square A Sponsor: AAPT Time: 1:30–3:30 p.m. Date: Monday, July 30 President: Trevor Smith

### BH01: 1:30–1:40 p.m. Assessing Instructors with Student Grades: Algebra-based Physics

Contributed – Srividya Suresh, the Ohio State University, 191 West Woodruff Ave., Columbus, OH 43210-1117; suresh.62@osu.edu  
Amber B. Simmons, Andrew Heckler, the Ohio State University

We are studying the effects instructor(s) have on student performances in subsequent courses. Most introductory physics courses come in a two-semester sequence and our project's main goal is to determine: does a given instructor add value or under-serve students as measured by student performances in the subsequent courses in the introductory physics series? We analyze data that includes student course grades, physics and math courses, mathematics placement exams, and standardized test scores. Additionally, our data also provides student demographics such as gender and ethnicity. The data includes students enrolled in the introductory physics courses from the fall term in 2012 to the summer term in 2017 at the Ohio State University, representing over 10,000 students and over 200 instructors. We will also present some preliminary results of the analysis. This presentation is one of two conference presentations on this project and will cover the algebra-based physics sequence.

### BH02: 1:40–1:50 p.m. Assessing Instructors with Student Grades: Calculus-based Physics

Contributed – Amber B. Simmons, The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210-1168; byrum.37@osu.edu  
Srividya Suresh, Andrew Heckler, The Ohio State University

We describe a project, now in its initial stages, to examine the effects of an individual instructor or populations of instructors on student performance in subsequent courses. The project analyzes course grade data of students enrolled in introductory physics courses anytime from the fall term of 2012 through the summer term of 2017 at The Ohio State University, representing over 10,000 students and over 200 instructors. The data includes grades in physics and math courses, cumulative GPA, standardized test math scores, and demographics such as major, race, and sex. The project is ultimately aimed at answering: does a given instructor (or category of instructor) add value or under-serve students as measured by student performance in the subsequent course in the introductory physics series? We will also present some preliminary results of the analysis. This presentation is one of two conference presentations on this project and will cover the calculus-based physics sequence.

### BH03: 1:50–2:00 p.m. Finding Student Learning Profiles Using Brief Survey of Study Habits

Contributed – Jarrad W.T. Pond, University of Georgia, Building 1003, Sanford Dr., Athens, GA 30602; jarradpond@gmail.com

Student learning profiles are a powerful tool for describing how students in one's classroom approach the subject material, both in their study strategies and their motivations. In general, a wide range of students' strategic self-regulatory and motivational characteristics are surveyed to ascertain a student's learning profile membership, leading to a lengthy student questionnaire. Results of previous analyses have suggested a paring down of survey items can be achieved without limiting the ability to resolve distinct student learning profiles. In this work, I will present the evaluation of several semesters worth of responses from a shortened questionnaire (composed of around 49 items probing self-regulatory and motivational characteristics), reporting on consistency with its lengthier version (around 73 items) and its ability to identify learning profiles among a population of students.

### BH04: 2:00–2:10 p.m. Daily Homework: A Study-Skills Strategy

Contributed – Robert W. Arts, University of Pikeville, 147 Sycamore St., Pikeville, KY 41501; RobertArts@upike.edu

Often in science courses homework problems are assigned in block sets that represent content throughout a topic. Students are encouraged to look over these problems following each lecture as a study aid for the material presented. More often than not, students wait until the due date for these problems sets to begin their attempts; resulting in a flurry of questions and concerns. This presentation will focus on the switch from these homework blocks to smaller daily assignments that represent content from an individual lecture. Logistical information about the assignments, a compare and contrast of block homework scores to those of daily homework scores for the same student group, and student feedback will be a part of the presentation.

### BH05: 2:10–2:20 p.m. Who Should Study Harder, and When?

Contributed – Zhongzhou Chen, University of Central Florida, 4111 Libra Drive, Room 153, Orlando, FL 32828; Zhongzhou.Chen@ucf.edu  
Andrea Tama, Geoffrey Garrido, Michael Mikulec, University of Central Florida  
Kyle Whitcomb, University of Pittsburgh

When is it a good idea to ask students to "spend more time studying"? Correlating learning behavior and effort with students' learning outcome at scale has always been a challenging question. Mastery-based online instructional design significantly improves our ability to answer this question by integrating formative assessment into the learning process. By analyzing data collected from multiple online learning modules using the UCF Obojobo platform, we're able to suggest the optimum amount of time that students should spend on studying each module, as well as identify those students who are probably spending an insufficient amount of time studying. In addition, it also identifies students who spend too much time and is likely struggling with the content. The results of this research could in the future lead to an automated system that provides students with personalized learning guidance.

### BH06: 2:20–2:30 p.m. Response-Shift Bias in the CLASS with Predicted and Retrospective Survey

Contributed – Ramesh Adhikari, Jacksonville University, 2800 University Blvd. N, Jacksonville, FL 32211; radhikari@ju.edu  
W. Brian Lane, Jacksonville University

The Colorado Learning Attitudes about Science Survey (CLASS) is an important tool for assessing shifts in students' beliefs and attitudes about learning physics. Instructors hope that students overcome their preconceptions about physics and complete the course with a favorable shift in their attitudes, but pre-to-post-instruction CLASS results usually indicate a decline. However, we have found that these results can contain response-shift bias due to students' changing frame of reference regarding the subject. We have observed significant gains when comparing post-instruction CLASS responses with retrospective responses. We also report responses to a CLASS administration that asked students to predict their end-of-semester responses. We compare traditional pre- and post-instruction responses with predicted and retrospective responses to the CLASS, with which we evaluate the presence and impact of response-shift bias within student responses.

**BH07: 2:30-2:40 pm. How Does the Question Affect Student Reflection?**

*Contributed – Petr M. Lebedev, University of Sydney, Physics Office, Room 210, Building A28 School of Physics, Physics road, Sydney, NSW 2006 Australia pleb0344@uni.sydney.edu.au*

*Manjula D. Sharma, University of Sydney*

Reflection enables us to correct distortions in our beliefs and errors in problem-solving Mezirow (1990). Our research deals with how reflection manifests after watching “Q&A” style physics education videos. In video one, four physics questions were asked, and in video two the solutions were given. We included a survey after the second video asking if the viewer changed their answers to the questions. If the viewer responded “no” the respondents were prompted to answer why they did not. There were 2200 respondents to our survey. 83.3 to 89.9% of the people who answered incorrectly reported that they changed their minds. The reasons given for not changing their minds were varied but were coded into seven distinct categories. The question played a large role. We are running this survey again with a group of 1000 first-year physics students and will attempt to identify how the question affects reflective thinking.

**BH08: 2:40-2:50 p.m. Engaging Students in Developing and Using Models through Assessments**

*Contributed – Katherine C. Ventura, Kansas State University, 625 Northfield Road, Manhattan, KS 66502; katventura@ksu.edu*

*James T. Laverty, Kansas State University*

Recent national reports have elevated learning how to do physics to the same level of importance as learning the concepts of physics. By making these “scientific practices” more prominent in assessments, we hope to see a shift in students’ focus toward the process of solving physics problems. Assessing scientific practices is important to determining if we, as educators, are facilitating students’ abilities to engage in the process of science. We are investigating how assessments can be designed to engage students in the practice of Developing and Using Models. Using a think-aloud protocol we interviewed students while working on these assessments and analyze the interviews using Grounded Theory. We are looking at two questions: do students engage with the practice and do students get the problem correct? Observing students’ engagement informs us how to develop assessments to engage students and how well we can assess practices.

**BH09: 2:50-3:00 p.m. Students’ Use of Mathematics While Working on Physics Assessments**

*Contributed – Amali Priyanka Jambuge, Kansas State University, 1600 Hillcrest Dr., Apt. V25, Manhattan, KS 66502; amali@phys.ksu.edu*

*James T. Laverty, Kansas State University*

Exams and homework are the most common ways of assessing students’ knowledge. These assessments often focus only on assessing physics concepts. With the introduction of the Next Generation Science Standards (NGSS), there is growing interest in assessing not just what students know, but what students can do with their knowledge. The Three-Dimensional Learning Assessment Protocol (3D-LAP) is a tool developed to help people design college assessment tasks that align with NGSS. The purpose of this study is to investigate how well such tasks can assess students’ abilities with the scientific practice “using mathematics”. We developed an exam with questions based on the 3D-LAP and the exams were given to students in an interview setting using a think-aloud protocol. This talk will focus on some interesting aspects of students’ responses to the questions. This work will inform the development of future college level physics assessments.

**BH10: 3:00-3:10 p.m. Using Large-Scale, Normative Data to Assess Physics Courses**

*Contributed – Jayson M. Nissen, California State University - Chico, 101 Holt Hall, Chico, CA 95929; jnissen1@csuchico.edu*

*Ben Van Dusen, California State University - Chico*

How effective is my teaching? For over 30 years, instructors have used concept inventories and attitudes surveys to help answer this question. Unfortunately, no large-scale datasets have existed to inform their answers. Instead, instructors have relied upon rough rules of thumb and intuition. LASSO is an online platform designed to help instructors answer this question. The platform administers, aggregates, and scores pre-/post-research-based assessments for instructors ([learningassistantalliance.org/modules/public/lasso.php](http://learningassistantalliance.org/modules/public/lasso.php)). Instructors receive a report on their students’ outcomes and can download all the data from their students. To support educators and researchers in assessing instruction, the LASSO development team is working on integrating normative, national-level data into the assessment reports. We will present analyses of concept inventory and attitudes surveys from over 300 introductory physics courses. Our discussion will cover how we intend to integrate these results into the LASSO platform to help researchers and instructors in assessing course outcomes.

**BH11: 3:10-3:20 p.m. The Long-Term Impact of Course Reforms**

*Contributed – James T. Laverty, Kansas State University, 213 Cardwell, Manhattan, KS 66506; laverty@ksu.edu*

*Santosh Budhathoki, Sarah Peterson, Dean Zollman, Kansas State University*

*Alice D. Churukian, The University of North Carolina at Chapel Hill*

Many research groups have spent time and effort reforming introductory physics courses over the years. One measure of success for these reforms is to see if learning gains on concept inventories increase over the prior, traditional approach. Kansas State University reformed its introductory calculus-based physics course in spring 2000 to include studios. In this talk, we compare the learning gains on the FCI immediately after the course reform to those currently being observed. The result is a significant drop from what they were just after the reform to now, but gains are still significantly higher than before the reform. We examine how the course has (and has not) changed over this time period to search for possible explanations for the drop in learning gains. We find a number of factors that do not seem to have an effect on this drop and speculate on some other possible reasons for it.

**BH12: 3:20-3:30 p.m. A Dashboard for Evaluating Student Engagement with PhET Simulations**

*Contributed – Diana Berenice Lopez Tavares, Polytechnic National Institute, Calzada Legaria 694, Mexico City, MEX 11500 Mexico dianab\_lopez@hotmail.com*

*Sam Reid, Katherine Perkins, University of Colorado Boulder*

*Carlos Aguirre-Velez, Polytechnic National Institute*

Student engagement with interactive simulations is affected by the prompts and activities teachers choose to couple with such simulations. In this work, we introduce a prototype dashboard to visualize and evaluate the level of student engagement generated by a PhET simulation activity. We compare student engagement resulting from two different prompts. The first prompt invites students to find the variables that affect stored energy in a capacitor through open exploration. The second prompt asks students to predict stored energy given specific parameters outside the simulation’s available range. Engagement in this study is gauged by multiple factors including the time spent in the activity, the rate and pattern of clicks, and the controls used in the sim. The dashboard uses several approaches to visualize student mouse activity data, showing individual student interaction patterns with the simulation as well as the aggregated information of an entire group.

## Session BI: PER: Student Content Understanding, Problem-Solving and Reasoning

Location: Mount Vernon Square B Sponsor: AAPT Time: 1:30–3:20 p.m. Date: Monday, July 30 President: Gen Long

### BI01: 1:30-1:40 p.m. Commonly Activated Conceptual Resources for Understanding Mechanical Wave Propagation

Contributed – Lisa M. Goodhew, University of Washington, 3910 15th Ave. NE, Seattle, WA 98195; goodhewl@uw.edu

Amy D. Robertson, Rachel E. Scherr, Seattle Pacific University

Paula R.L. Heron, University of Washington

In a resources theory of knowledge, new knowledge is constructed from existing knowledge elements—called resources—that are activated in real-time, in context-sensitive ways. These resources are thought to be derived from experience and continuous with formal physics concepts. Despite proposed benefits of instruction that builds upon student resources, little research has been done to investigate the common resources that students use as they reason about physics concepts. Our work contributes to the conversation on resources-oriented physics instruction by investigating the common conceptual resources that students use to reason about mechanical wave propagation. In this talk, we will present our analysis of written responses to conceptual physics questions that were administered to introductory physics students at multiple institutions across the United States. We will focus on the resources that are commonly activated in wave propagation scenarios, with an eye toward how our results can inform instruction that takes up and builds upon student thinking.

### BI02: 1:40-1:50 p.m. A Comparison of Visual Representations of E&M Plane Waves

Contributed – Michael B. Wilson, North Carolina State University, 421 Riddick Hall, Campus Box 8202, Raleigh, NC 27695; mbwilson@ncsu.edu

Robert Beichner, North Carolina State University

It is well known that plane waves in electricity and magnetism (E&M) are misunderstood. Particularly, the traditional visual representation of these plane waves is misleading, and students are confused by the waves' three dimensionality. A possible improvement has been designed using an animated vector field. Graduate physics students were presented each visual representation of E&M plane waves. The students were asked to describe what each visual represents in detail. Students' reactions to those two representations is compared, and insight into the content delivered in each visualization is interpreted as well as insight into the direction of future research on this topic.

### BI05: 2:10-2:20 p.m. Improving Student Understanding of the Many-Particle Hamiltonian and Stationary-State Wavefunction for Non-interacting Identical Particles\*

Contributed – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Christof Keebaugh, Emily Marshman, University of Pittsburgh

We discuss an investigation of student difficulties with the many-particle Hamiltonian and stationary state wavefunction for a system of non-interacting identical particles. The investigation was carried out in advanced quantum mechanics courses by administering free-response and multiple-choice questions and conducting individual interviews with students. We discuss the common student difficulties related to these concepts. These findings are being used as a guide for creating learning tools to help students develop a functional understanding of concepts involving the many-particle Hamiltonian and stationary state wavefunction for a system of non-interacting identical particles.

\*We thank the National Science Foundation for support.

### BI06: 2:20-2:30 p.m. Student Reasoning about Eigenvectors and Eigenvalues from a Resources Perspective

Contributed – Warren M. Christensen, North Dakota State University, 513 9th Ave. N, Fargo, ND 58102; warren.christensen@ndsu.edu

Kevin Watson, Megan Wawro, Virginia Tech

Eigentheory is an important mathematical tool for modeling quantum mechanical systems. A growing body of literature exists in the Research in Undergraduate Mathematics Education community on student thinking about Linear Algebra concepts, but little is known about the reasoning available to physics students about eigenvectors and eigenvalues as they transition from linear algebra courses into quantum mechanics. Interviews were conducted at the beginning of the semester with eight students enrolled in a course on Quantum Mechanics. One-on-one, semi-structured interviews were transcribed and analyzed using a resources framework by one PER and two RUME researchers. This work will highlight examples of the resources identified in physics students' reasoning about the eigenvectors and eigenvalues of a real 2x2 matrix, as well as connections among these resources within and across students.

### BI07: 2:30-2:40 p.m. How Students Apply Linear Algebra to Quantum Mechanics

Contributed – Charlotte Hillebrand-Viljoen, University of Cape Town, Department of Physics, Cape Town, Western Cape 7701 South Africa c.s.hillebrand@gmail.com

Spencer Wheaton, University of Cape Town

I present results from a qualitative study investigating student and expert strategies for applying mathematics to physics, and particularly linear algebra to quantum mechanics. I discuss results around three facets of this topic. The first of these describe student understanding of the usefulness of linear algebra, and how this can evolve toward greater sophistication. Second, I describe mental models of the wavefunction and discuss evidence that suggests sophisticated models of the wavefunction are underpinned by specific ways of thinking about vectors. Lastly, I consider applications of maths to physics through epistemic games, noting the importance of engaging in both physics-story and maths-story spaces to solve complex problems. I highlight some reasons that students may not play this epistemic game when solving physics problems. All these results have implications for instruction, either in the context of quantum mechanics or more broadly in physics, and I discuss these in each case.

### BI08: 2:40-2:50 p.m. How Students' Understanding of Normalization Changes After Taking Quantum Mechanics

Contributed – Kevin L. Watson, Virginia Tech, 4210 Christie Lane, Christiansburg, VA 24073; wk223@vt.edu

Normalization is a particularly important concept within quantum mechanics due to the probabilistic nature of quantum systems. However, students' understanding of normalization has not been well studied in the past. In this contributed talk, I will share insights from analyzing physics students' understanding of normalization through the use of a framework for students' understanding of mathematical norms and normalization of vectors. More specifically, I will compare and contrast

students' understandings of normalization before and after taking an introductory quantum mechanics course. Through the results, I will demonstrate that a majority of physics students enter quantum mechanics with a narrow or incomplete understanding of normalization, but through learning quantum mechanics content and introduction of new notational systems (i.e., Dirac notation), these students can leave quantum mechanics with a more complete understanding of normalization and its importance to physics.

**BI09: 2:50-3:00 p.m. Representational Choices When Solving Expectation Value Problems**

*Contributed – Gina Passante, California State University Fullerton, Physics Department, 800 N. State College Blvd. Fullerton, CA 92831; gpassante@fullerton.edu  
Steven J. Pollock, University of Colorado, Boulder; Homeyra R. Sadaghiani, California State Polytechnic University, Pomona*

In quantum mechanics, one is often interested in the expectation value of different quantities. Expectation values are somewhat unique in the sense that they are asked for on exams throughout the course. For example, it is common to see expectation values in the context of the infinite square well, spin-1/2 particles, and the hydrogen atom. We analyze student responses to expectation value exam questions in each of these contexts, focusing on students' choice of representation and the method they use to calculate their answer.

**BI10: 3:00-3:10 p.m. How Students Narrow a Representation to Find a Partial Derivative**

*Contributed – Paul J. Emigh, 2410 NW Rolling Green Dr. Apt. 41, Corvallis, OR 97330; paul.emigh@gmail.com  
Corinne A. Manogue, Oregon State University*

At Oregon State University, we are examining how students solve problems that involve partial derivatives. This effort is part of defining a learning progression that spans undergraduate mathematics and physics courses. One area of focus is to investigate how students find partial derivatives from contour graphs, which are common in both electromagnetism and thermodynamics courses. We report results from open-ended problem-solving interviews with upper-division physics students. Our findings include that, when finding a derivative, students took a given contour graph (relating three or four variables) and "narrowed" the representation to a relationship between only two variables. We discuss how students chose which two-variable relationships to narrow to, or how they failed to narrow, and how they did or did not find a partial derivative from such a relationship.

**BI11: 3:10-3:20 p.m. Student Investigations of Variables in a Thermodynamics Transfer Problem**

*Contributed – Michael Vignal, Oregon State University, 700 NW 5th St Unit 18, Corvallis, OR, 97330; vignalm@oregonstate.edu  
Paul J. Emigh, Elizabeth Gire, Oregon State University*

Proper treatment of dependent and independent variables in middle- and upper-division thermodynamics is critical for student success. We explore the different ways in which students reason about variables while solving a thermodynamics problem. Our data comes from 12 teaching interviews with middle-division undergraduate physics majors. In these interviews, we taught students how to perform a Legendre Transformation in one setting, then we asked them to solve an analogous problem for a typical thermodynamics situation. In this talk, we discuss how students investigated and reached conclusions about dependent and independent variables during the transfer problem.

**Session BJ: PTRAs Developing Women in Physics in K-12**

**Location:** Meeting Room 3 **Sponsor:** Committee on Women in Physics **Co-Sponsor:** Committee on Teacher Preparation **Time:** 1:30–3:30 p.m.  
**Date:** Monday, July 30 **President:** Linda Fox

**BJ01: 1:30-2:00 p.m. Learning from the Past While Looking to the Future**

*Invited – Karen Jo Matsler, UT Arlington, 3743 Hollow Creek, Arlington, TX 76001; kjmatsler@gmail.com*

In an effort to address the needs of K-12 educators in physics and physical science, data has been collected from hundreds of PTRAs institutes and workshops across the country for over 10 years. Results have exposed trends that have been useful in developing and aligning effective professional development and support, especially for those with limited content background. In order to develop women in physics, one must identify areas of content understanding and help teachers increase in confidence. Changing a culture is difficult, but this session will highlight what we learned from the past, how we are addressing those challenges now, and discuss how we are facing the future challenges.

**BJ02: 2:00-2:30 p.m. Pushing Forward: The Complexity of Women in Physics in K12**

*Invited – Justine Boecker, Fridley High School, 2799 Rustic Place, St. Paul, MN 55117; jub95553@bethel.edu*

The discrepancy between men and women in physics has been a consistent issue throughout history that is far more complex than we might expect. Beginning the semester I sat in my sophomore level physics course being one of only three women in a class of over 30, I got involved in movements to change this gender gap. I began my initiatives at the college level by forming the first Women in Physics group at my school. However, I realized the problem originates far before college. I continued seeking interventions and solutions at younger ages. With specific intervention experiences in higher education, high school, elementary and early childhood, I have developed an understanding for the complexity of the issue. There is not one strategy that will close the gap, but each effort is worth the change and opportunity of each additional woman in physics to push us forward.

**BJ03: 2:30-3:00 p.m. Developing Women in Physics in K-12 Education**

*Invited – Ann Robinson, University of West Georgia, Maple Street, Dallas, GA 30118; arobinso@westga.edu*

Developing Women in K-12 education is about overcoming two barriers. The first is changing their attitude about science and math. In an Attitudes Toward Science Survey all of the teachers agreed science and math are important in everyday life; however, they felt insecure and had no self-confidence about doing well in science. They must overcome the fear and dislike of science and math in order to teach these subjects. The next obstacle is helping them become comfortable with the activities and concepts in physics. Both hurdles can be jumped by using the PTRAs model of workshop instruction. PTRAs methodology is to help teachers not feel threatened or inadequate when confronted with new ideas and methods of teaching. When women are safe to ask questions and address misconceptions, they are free to resolve fears concerning STEM. The workshops are activity/participant centered using methods and materials the teachers will be relaxed using.

**BJ04: 3:00-3:30 p.m. Developing Women Physics Teachers**

Invited – Jill Marshall, University of Texas, 1 University Station D5700, Austin, TX 78703-2821; marshall@austin.utexas.edu

Although the role of teacher, particularly at the pre-college level, is one that has traditionally been associated with women, this has not always been the case in the discipline of physics. As recently as 2009, only 32% of high school physics teachers were women. In states like Texas, where high school teachers are essentially required to have a major in the discipline that they teach, the problem is exacerbated by the lower numbers of women physics majors. The UTeach program addresses this need by providing special training for students to certify as Composite Science teachers, but UTeach was also instrumental in the establishment of Physics/Math and Mathematics, Physical Science, Engineering certifications in Texas. I will describe the UTeach teacher preparation training and also report on our successes in preparing women to become physics teachers.

**Session BK: Remembering Millie Dresselhaus**

**Location:** Meeting Room 4    **Sponsor:** Committee on the Interests of Senior Physicists    **Co-Sponsor:** Committee on Women in Physics    **Time:** 1:30–3:30 p.m.  
**Date:** Monday, July 30    **President:** Lila Adair

**BK01: 1:30-2:00 p.m. Mildred Dresselhaus and Solid State Pedagogy at MIT**

Invited – Joseph D. Martin, \* University of Cambridge, Department of HPS / Free School Lane, Cambridge, CAMBS CB2 3RH United Kingdom jdm205@cam.ac.uk

Mildred Dresselhaus's MIT teaching career began in 1967, when she transitioned to the institute from the Lincoln Laboratory. Despite being an international center for solid state physics research, MIT had a dearth of relevant courses on the books. John Slater's group in the physics department taught a brand of solid state theory too abstract for most applied physics and engineering students. And the recently formed National Magnet Laboratory, although it conducted considerable in-house graduate supervision, offered little in the way of essential coursework. It was left to Dresselhaus to craft a pedagogical approach that was responsible to the intellectual foundations of solid state physics while remaining accessible to MIT's engineering and applied physics students. The result—recorded in course notes and oral histories—is both a testament to Dresselhaus's skill as a physics teacher, and a snapshot of a larger transition American solid state physics was undergoing at the time.

\*Sponsored by Lila Adair

**BK02: 2:00-2:30 p.m. My Millie Memories: Superb Teacher and Lifelong Mentor**

Invited – Aviva Brecher, USDOT Volpe Center-retired, 35 Madison St., Belmont, MA 02478; avivabrecher@hotmail.com

I reminisce on how profoundly Millie affected my career and personal life in 50 years of mentorship, lifelong career guidance, and friendship. My personal MIT experience is typical of her lasting impacts on broader opportunities, and improved climate for women in S&T professions. Stories of Millie as my role model illustrate her hands-on approach to mentoring and improving career opportunities. I took her first Solid State Physics course at MIT in 1968. She was a superb teacher, using Fermi's method of clear lecture handouts, and encouraging questions to inspire new research. As a postdoc, I attended her weekly MIT meetings with women students, staff and faculty to identify problems and implement solutions. Her advice on balancing work and family life, and dedicated mentorship shaped my and many other careers. Her leadership on professional associations, the Academies, DOE and National Labs has changed national policies and best practices.

**BK03: 2:30-3:00 p.m. Millie Dresselhaus at the Office of Science**

Invited – Harriet Kung, \* Office of Science, Department of Energy, OFFICE OF SCIENCE U.S. Department of Energy, 1000 Independence Ave., SW, Washington, DC 20585; Harriet.Kung@science.doe.gov

Dr. Mildred (Millie) Dresselhaus served as the director of the Department of Energy's Office of Science (SC) during 2000 – 2001. She was the seventh director of SC (and its predecessor, the Office of Energy Research) since the founding of the Department of Energy in 1977. Prof. Dresselhaus took over the reins of SC during a time of significant fiscal challenges, with flat to declining budgets in the preceding decade. The fiscal year 2000 was the turning point for SC, reversing the funding trend to start a gradual increase of the Office's budget and scope. Millie insisted on a balanced strategy to ensure that the growth in scientific user facilities was balanced with funding for research. Despite her short tenure in DOE, the foundation she established set the framework for SC in the ensuing decades. Prof. Dresselhaus continued to advance U.S. science and the missions of SC beyond her Directorship. Most notably, she led and initiated a few community-based strategic planning activities to chart the course of the "Science for Energy" strategy. This talk will highlight Millie's major contributions to the DOE Office of Science, including a range of anecdotal stories and testimonies collected from those whose lives and careers were intimately touched by Millie.

\*Sponsored by Lila Adair

**BK04: 3:00-3:30 p.m. Teaching the Physics Family**

Invited – Leora E. Dresselhaus-Cooper, Lawrence Postdoctoral Fellow, Physics Division, PLS, LLNL, CAMBRIDGE, MA 02139; dresselhaus1@llnl.gov

Prof. Mildred S. Dresselhaus spent her whole career shaping the physics community to be cohesive—like a family. As her granddaughter, I learned science through the lens of the "physics family," but beyond me, her lessons and mentorship shaped the scientific community globally. Between her classes, lectures, conference talks and seminars, Millie taught thousands of early-career students how to find their passions and how to pursue those passions while contributing to society. Millie taught and empowered generations of people to inspire those who came next, and today, we can see her web of teachers continuing to spread her legacy and strong values. This talk will provide the family perspective of how Millie's teaching style shaped the science and society we see today.

Prepared by LLNL under Contract DE-AC52-07NA27344.



## Session BL: Technology for Accessibility and Inclusion

**Location:** Marriott Marquis - Cherry Blossom **Sponsor:** Committee on Educational Technologies **Co-Sponsor:** Committee on Diversity in Physics **Time:** 1:30–2:50 p.m.

**Date:** Monday, July 30 **President:** Brianne Gutmann

### BL01: 1:30-2:00 p.m. Accessing Students' Voices

*Invited – Andy Rundquist, Hamline University, 1536 Hewitt Ave., MS B1807, Saint Paul, MN 55104; arundquist@hamline.edu*

Using a Standards-based Grading approach has enabled me to work with students to help them master the material we are investigating. By providing multiple opportunities for the students to demonstrate their mastery, I hope to be as open as possible for the students. By focusing on oral exams and student-submitted videos of their work, I have begun to access the students' authentic voices. While some students are frustrated that just getting the right answer isn't enough, others struggle with articulating their learning to me. I'll talk about the value I see in this approach along with challenges I face making sure that all students are well served.

### BL02: 2:00-2:30 p.m. Hybrid Spaces and Third Places for Scientizing with Mobile, Wearable, & Community Technologies

*Invited – Tamara Clegg,\* University of Maryland, 4310 Campus Dr. Rm. 2117J, College Park, MD 20742; tclegg@umd.edu*

Emerging technologies have the potential to enable new forms of hybrid spaces for promoting scientizing experiences that can help learners, especially those from groups underrepresented in STEM to engage in STEM practices. In these hybrid spaces, science practice can become deeply intertwined with learners' everyday lives, cultures, and values. One such genre of technology -- live physiological sensing and visualization (LPSV) tools -- will be presented in this talk. LPSV tools sense and visualize learners' internal organ functioning (i.e., heart rate, breathing rate) in real time on an e-textile shirt and a large-screen display. I will present ways in which elementary school children at a local urban public school developed scientizing practices as they designed new science experiments with LPSV tools and insights about ways LPSV hybrid spaces can be designed to support learners' scientizing practices. Next, taking a community-based approach, I will present two Third Place contexts for supporting place-based and cross-setting scientizing experiences that also have potential for broadening engagement in STEM. Oldenburg characterizes Third Places as places in which informal public life develops dynamically. Building on this definition, I will discuss a process that I call Third Place Design, where I leverage co-design with community members (i.e., youth, parents, teachers, informal educators, community volunteers) and iterative integration of new technologies into Third Place contexts in two projects. From my Third Place Design process in these projects, I will identify ways social media and community-based technologies (i.e., large interactive displays) can support community scientizing practices in community settings.

\*Sponsored by Katie Ansell

### BL03: 2:30-2:40 p.m. Learning with a Concussion (and other Oxymorons)

*Contributed – Colin M. Fredericks, Harvard, 42 Rawson Road, Arlington, MA 02474; colin.fredericks@gmail.com*

If you were at the 2017 AAPT Summer Meeting, you may have seen someone fall off the back of the stage at the end of the demo show. That was me. I didn't know it that night, but I had suffered a traumatic brain injury that kept me out of work for several weeks, and unable to function at full capacity for months. This talk uses my own path back to health to frame suggestions (both technological and otherwise) for how to help concussed students while they recover.

### BL04: 2:40-2:50 p.m. Twenty Years of Distance/Online Physics Education: A Field Report

*Contributed – John Matthew Long, Deakin University, School of Engineering, locked bag 20000, 75 Pigdons Road, Geelong, VIC 3220 Australia; john.long@deakin.edu.au*

In recent years there has been an increased interest in teaching physics by means of online and distance education. Students who benefit are those who live in remote areas, students posted overseas, students who lack mobility, and even students who work during the day where suitable evening classes are not available. In spite of this interest there are few reports of physics being taught in this manner. Deakin University in Australia has been teaching introductory physics for engineers simultaneously to both on-campus and off-campus students since 1996. This presentation outlines the advances made in delivering education in physics to a wide variety of distance students. Teaching materials have developed from written study guides to fully online and video-based teaching materials. Tutorials are delivered to off-campus students by web-conferencing. Numerous strategies have been trialed to deliver lab and practical training off-campus. Challenges and how they were overcome will also be discussed.

## Session BM(A): Scientific Activism

**Location:** Meeting Room 10/11 **Sponsor:** Committee on Physics in Two-Year Colleges **Co-Sponsor:** Committee on Professional Concerns **Time:** 1:30–2:30 p.m.

**Date:** Monday, July 30 **President:** Renee Lathrop

### BM(A)01: 1:30-2:00 p.m. The Faculty Role in Advocacy: What, Why, and How

*Invited – Scott Franklin, Rochester Institute of Technology, 1 Lomb Memorial Drive, Rochester, NY 14623-5603; svfsps@rit.edu*

The Capitol Hill environment is completely unlike that in the halls of academia and advocating for science policy requires a style of communication quite different from scientific discourse. Nevertheless, the experience, while challenging, is both incredibly important and transformative in how one approaches changing our educational system. There are a growing number of resources that faculty can draw upon to make the process easier and more effective. I will discuss my trips to Capitol Hill, including the details of setting up and managing appointments with congressional aides, and the resources I used during my visits. I'll also describe the initial culture shock and how I quickly came to appreciate the intensity and clarity of the visits. Finally, this talk will provide a roadmap for other faculty wishing to advocate for science policy and a hands-on example in identifying, contacting and communicating with representatives and their offices.

### BM(A)02: 2:00-2:10 p.m. Science, Society, and Ethics in Introductory Physics

*Contributed – Eric C. Martell, Phoenix Country Day School, 3901 E Stanford Dr., Paradise Valley, AZ 85253; eric.martell@pcds.org*

Educated people not only have the skills and knowledge to be successful in their lives but also the responsibility to be active members of their community. Through assignments given during introductory physics courses, "Science and Society" and "Science and Ethics," I hope to give my students a foundation to do just that. In the first project, they choose a problem of interest to them where understanding the science is a crucial part of understanding the problem and reach out to an audience outside the classroom — community group, member of state government, member of Congress, etc. — to raise awareness and understanding of the issue. In the second, they develop a normative ethical argument regarding an issue of importance to them and use science to craft an argument supporting their position. They are required to respectfully express the opposing position, hopefully developing a thoughtful and empathetic approach to rhetorical argument.

**BM(A)03: 2:10-2:30 p.m. Exploring How Academic Institutions Prepare Workforce Development and Progression into the Physics Global Community**

*Contributed – RHF H. Freeman, Northcentral University, 6900 North Ocean Blvd. #1001 Myrtle Beach, SC 29572; ronhfreeman@yahoo.com*

National Science Foundation considers U.S. workforce development in physics to include (1) Physics Outreach, (2) Physics Frontier Centers, and (3) Physics Global Community. Physics Frontier Centers foster major advances by providing needed resources to develop a specialized infrastructure not normally accessible to individual investigators. And, in Physics Global Community, international efforts to produce science from large scale Laser Interferometer Gravitational-wave Observatory, Large Hadron Collider, and IceCube neutrino observatory programs provide opportunities to participate in the cyber infrastructure of Open Science Grid. Therefore, the global scope of physics-specific workforce has an important role in the advancement of the science. Large scale projects such as QuarkNet, Center for HEP Research and Education Outreach (CHEPREO), Cosmic Ray Observatory Project (CROP), and Astrophysics Science Project Integrating Research and Education (ASPIRE) help students gain skills and knowledge to mainstream technologically into the workforce. However, with the growing physics global community, of which US shares variable engagement, this paper aims to comparatively evaluate prospectus within the global workforce physics specializations and to provide a comparative analysis of how national education systems prepare the workforce for their entry.

**Session BM(B): Science, Society and Outreach**

**Location:** Meeting Room 10/11 **Sponsor:** AAPT **Time:** 2:30–3:30 p.m. **Date:** Monday, July 30 **President:** Renee Lathrop

**BM(B)01: 2:30-2:40 p.m. Educational Issues Pertaining to Claims about Anthropogenic Climate Change**

*Contributed – Laurence I. Gould, University of Hartford, Physics Dept., 200 Bloomfield Ave., West Hartford, CT 06117-0395; lgould@hartford.edu*

Many arguments have been made that — as a result of human activities that emit greenhouse gases (mainly carbon dioxide) — there is a dangerous trend of increasing global temperatures resulting in events such as melting glaciers, rising sea levels, and increased storms. This talk draws on topics from a one-semester freshman seminar course taught at the University of Hartford in 2009, 2014, and 2017. The course was devoted to a critical-thinking approach to the topic of Anthropogenic Climate Change. The presentation will — through an analysis that includes some of those arguments and methodologies — show how curious people can seek a deeper understanding of the issues and thus enhance their ability at scientific inquiry. The material should be of particular interest to students and educators.

\*Gould, L.I. "Systematic And Logical Problems In Global Warming Science" ENERGY & ENVIRONMENT Volume 25 - No. 6 & 7, 1205 - 1219 (2014)

**BM(B)02: 2:40-2:50 p.m. Just Science: Student Responses to Social Issues in Science**

*Contributed – Dicha Perez, \* CSU Chico, 400 W. 1st St., Chico, CA 95929; dperez-montalvo@mail.csuchico.edu*

*Carolina Alvarado, CSU Chico*

NGSS Framework for K-12 Science Education uses disciplinary core concepts to support students in developing critical thinking through investigation. We explore a course for pre-service teachers that develops evidence-based argumentation skills through conducting inquiry experiments. This course, designed to push students to practice these skills beyond the science classroom will create critically reflective individuals. As part of the regular curriculum, the instructor included statistical data on inequities in the STEM fields. After exposing students to social justice issues in STEM, they were offered extra-credit assignments addressing this topic, requiring students to use evidence-based argumentation to participate in conversation on social justice. We analyze student's written responses to these interventions studying their reactions to having explicit conversations of inequities in STEM in a science course. We consider embedding social justice topics within science courses, especially for future teachers, will support agency to change inequities in STEM.

Sponsored by Dr.Carolina Alvarado

**BM(B)03: 2:50-3 p.m. Preparing 21st Century Global Citizens through STEM Education**

*Contributed – Hai D. Nguyen, Tennessee Wesleyan University, 204 East College St., Athens, TN 37303; hnguyen@tnwesleyan.edu*

*Hang Tran, Stemhouse Education*

In the past few years, Science, Technology, Engineering and Mathematics (STEM) education has gained more and more interest of science educators, educational policy makers and society, not only because of the importance of these disciplines in the modern world but also because of the many skills and characters of the 21st century global citizens it can build for young students. In this talk, we share our experience in STEM education in a developing country (Vietnam) and discuss how we prepare our students to be 21st century global citizens. We also seek for international collaborations to further strengthen our ability and broaden our network for our students.

**BM(B)04: 3:00-3:10 p.m. Physics Innovation for Global Learning and Leadership Development Curriculum**

*Contributed – Nicole L. Ackerman, Agnes Scott College, 141 E. College Ave., Decatur, GA 30030-3770; nackerman@agnesscott.edu*

*Amy J. Lovell, Chris G. De Pree, Agnes Scott College*

For the last three years, Agnes Scott College's SUMMIT curriculum has emphasized leadership development and global learning. The Physics and Astronomy Department has enthusiastically participated through transforming courses, creating new courses, and offering extracurricular programming. Part of the curricular change removed the laboratory science general education requirement, so our departmental role in the college has needed to dramatically shift. We have redesigned Calculus-Based Intro Physics and Intro Astronomy to focus on teamwork (a leadership skill) and have focused Practical Electronics and Intro to Python on digital literacy (a leadership skill). On the Global Learning side, we created a studio-approach general education course on Global Music and Physics and lead first-year students on a trip to the Arctic to study climate and energy sustainability. We also are teaching in the core first-year leadership and global classes, as well as the senior portfolio capstone. Throughout this process we have created new leadership experiences for students and redesigned the physics major to better facilitate study abroad. Connecting physics and astronomy to leadership development and global learning has been an enriching experience and this talk may inspire you to see ways the physics curriculum can serve wider general education and career development goals.

**BM(B)05: 3:10-3:20 p.m. Real Physics Live**

*Contributed – Tatiana Erukhimova, Texas A&M University, 4242 TAMU, College Station, TX 77843-4242; etanya@tamu.edu*

Real Physics Live is a set of short, entertaining videos presenting exciting physics experiments performed by Texas A&M students. Our target audience is K-12 students. Each video explains and illustrates one physics concept or law through a fast-paced sequence of physics demonstrations and experiments. The cast consists entirely of physics students with artistic abilities and substantial experience in showing physics demonstrations at current outreach events run by the department: Physics Shows and Physics & Engineering Festival. The students are of almost the same age as their high-school audience. They are in the best position to connect with kids and convey their fascination with physics. The PI and other faculty members who are involved in the outreach advise and coach the cast. They help students in staging the episodes and choosing the most exciting and relevant demonstrations. This project was funded by the APS mini outreach grant.

**BM(B)06: 3:20-3:30 p.m. Reducing Fear of Physics in Middle/High School Students through Physics Festival at Undergraduate Institution**

*Contributed – Pratheesh Jakkala, Illinois College, 1101 W College Ave., Jacksonville, IL 62650; pratheesh.jakkala@ic.edu*

*Joseph Johnson, Mercyhurst University*

This presentation will outline the experience of a college physics professor in planning, organizing, and implementing a physics festival for local middle and high school students. Over 300 middle and high school students were invited to attend with 30 undergraduate students assisting in the implementation of the event. The goals for this project include reducing the fear of physics in middle/high school students and providing a unique learning experience in physics for undergraduate physics students through designing and constructing the projects for the physics festival. The presentation will also discuss initial findings comparing the recorded goals of the implementing professor to the reported outcomes as described by the participating physics students.

**Plenary: A Conversation with Shirley Malcom**

**Location:** Renaissance Ballroom    **Sponsor:** AAPT    **Time:** 4–5 p.m.    **Date:** Monday, July 30    **Presider:** Mel Sabella



Shirley Malcom, AAAS

In this plenary session we have invited four members of the diverse AAPT community to participate in a discussion with Dr. Malcom. Shirley Malcom is Head of Education and Human Resources Programs of the American Association for the Advancement of Science (AAAS). The directorate includes AAAS programs in education, activities for underrepresented groups, and public understanding of science and technology. AAPT members participating in this conversation represent students, high school teachers, two year college faculty, and four year college and university faculty. Representatives from each group will ask Dr. Malcom pressing questions from their unique perspectives about the state of science education. In this setting we leverage the expertise of Dr. Malcom, as well as the expertise of AAPT members, in developing a better understanding of the science education landscape.

**Participants in the conversation:**

*Shirley Malcom, Director, Education and Human Resources Programs (EHR) American Association for the Advancement of Science (AAAS)*

*Facilitator: Bethany Johns, American Institute of Physics*

*Student representative: Eleanor Hook, Rhodes College*

*High School representative: Alice Flarend, Bellwood-Antis High School*

*Two Year College representative: Arlisa Richardson, Chandler-Gilbert Community College*

*Four Year College and University representative: Scott Franklin, Rochester Institute of Technology*

## Session CA: PER: Laboratories and Experiments

Location: Mount Vernon Square A Sponsor: AAPT /PER Time: 5–6:30 p.m. Date: Monday, July 30 President: Sam Sampere

### CA01: 5:00-5:10 p.m. "I'm Stuck!": Challenges of Proposing Causes for Unexpected Experimental Results

Contributed – Laura Rios, CU Boulder/JILA, Department of Physics, Duane Physics E1B32, Boulder, CO 80309-0390; [Laura.Rios@colorado.edu](mailto:Laura.Rios@colorado.edu)  
Heather J. Lewandowski, CU Boulder/JILA

Models are representations used to explain and predict experimental results. The process of constructing, testing, and refining models and apparatus is a common experimental practice. When physicists encounter discrepancies between observed and predicted behavior, they revise their models to be consistent with their observations, or modify their apparatus to better align with their model of the system. The Modeling Framework describes the process of matching measurements/observations to predictions. We used the Modeling Framework to develop and analyze think-aloud interviews centered on troubleshooting an inverting amplifying circuit. We observed that physics students are often unable to propose causes for an observed discrepancy. However, after modifying the circuit or measurement equipment, they then propose a cause for the original discrepancy post hoc. In this presentation, I contrast student approaches to resolving discrepancies. In one approach, students propose causes before enacting revisions; in the other, they propose causes afterward.

### CA02: 5:10-5:20 p.m. Student Understanding of Measurement and Uncertainty

Contributed – Nuraan Majiet, University of Cape Town, Department of Physics, Rondebosch, Western Cape 7700 South Africa; [mjtnur001@myuct.ac.za](mailto:mjtnur001@myuct.ac.za)  
Saalih Allie, University of Cape Town

The present work is part of a broad programme aimed at understanding how students think about data obtained from measurement, including measurement uncertainty, at a more fine-grained level than that obtained from the Physics Measurement Questionnaire. More specifically, do shifts from a point to a set paradigm result from deep conceptual change or are they the result of recognizing familiar situations that can successfully be processed according to appropriate prescriptions. In order to probe these finer grained aspects a process of developing a suitable instrument was initiated. The first phase of the process involved piloting individual, specific questions. The present talk will discuss the questions that were developed and piloted with a group of students after an introductory lab course. The focus of the talk will be on the quality and usefulness of the responses that were obtained.

### CA03: 5:20-5:30 p.m. Investigating Student Design of Electronic Systems in Physics and Engineering\*

Contributed – Kevin L. Van De Bogart, University of Maine, 5709 Bennett Hall, Orono, ME 04469; [kevin.vandebogart@maine.edu](mailto:kevin.vandebogart@maine.edu)  
MacKenzie R. Stetzer, University of Maine

Upper-division laboratory courses provide students with an important opportunity to learn and develop skills that are critical for experimental physics. In particular, such courses may require students to design, model, and troubleshoot a variety of systems. As part of an ongoing effort to investigate the learning and teaching of electronics, we have begun to examine student approaches to circuit design. While there is a large research base exploring the design process across several branches of engineering, very few of these studies have expressly focused on circuit design in electronics. To this end, we have conducted a series of think-aloud interviews in which students were asked to design circuits for practical, everyday applications. The resulting transcripts were analyzed to investigate the nature of student design approaches. In this talk, we present preliminary results and share illustrative examples of student work.

\*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1323426 and DRL-0962805.

### CA04: 5:30-5:40 p.m. Student Learning in a Design Versus Non-design Experiment in a Second-year Laboratory Course

Contributed – Bei Cai, Queen's University, 64 Bader Lane, Kingston, ON K7L 3N6 Canada; [beicai@queensu.ca](mailto:beicai@queensu.ca)  
Lindsay Mainhood, Robert Knobel

We redesigned an advanced physics laboratory course to include a project component. The intention was to address learning outcomes such as modeling, design of experiments, teamwork, and developing technical skills for using apparatus and analyzing data. The course included experimental labs in preparation for a six-week team project in which students designed and implemented a research experiment. The final assignment given to students was a reflective essay, which asked students to discuss their learning and satisfaction in doing the project. Qualitative analysis of the students' reflections showed that the majority of the students reported satisfaction and achievement, functional team dynamics, learning outcomes unique to this experience, practicing modeling skills, and potential future improvements. We suggest that reflections are useful as support for student learning as well as in guiding curricular improvements. Our findings may be useful for other course redesign initiatives incorporating project-based learning and student reflections.

### CA05: 5:40-5:50 p.m. The Impact of Student Behaviour in Physics Lab Classes

Contributed – Katherine N. Quinn, Cornell University, 245 East Ave., Ithaca, NY 14853-2801; [knq2@cornell.edu](mailto:knq2@cornell.edu)  
Michelle M. Kelley, Kathryn L. McGill, Emily M. Smith, N.G. Holmes, Cornell University

While laboratory instruction is a cornerstone of physics education, the impact of student behaviours in labs on learning and performance remain an open question. In this study, we performed in-lab observations of student actions over two semesters in two pedagogically different sections of the same introductory physics course. We used a cluster analysis to identify different categories of student behaviour and analysed how they correlate with factors such as gender, lab structure, time, and performance on the Physics Lab Inventory of Critical thinking (PLIC) and the Colorado Learning Attitudes About Science Survey for Experimental Physics (E-CLASS). We report our preliminary findings.

### CA06: 5:50-6 p.m. What Counts in Laboratories: Developing a Practice-based Identity Survey

Contributed – Kelsey M. Funkhouser, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824; [United States kfunkh@msu.edu](mailto:United States kfunkh@msu.edu)  
Marcos D. Cabellero, Paul W. Irving, Vashti Sawtelle, Michigan State University

An essential step in the process of developing a physics identity is the opportunity to engage in authentic physics practices. Physics laboratory courses are generally structured as a place for students to gain experience with physics practices. This makes laboratory courses an ideal place to look at the impact these authentic science practices have on students' physics identity. As part of the development of a practice-based identity survey, we have interviewed students in a variety of physics lab classes, from intro algebra based to advanced lab, to gain insight into their interpretations of different commonly discussed practices. To ground our survey in stu-

dents' experiences, we have asked questions about what these practices mean to the students. We present our findings on how students interpret these practices and situate themselves with respect to the practices as an indicator of their physics identity.

**CA07: 6:00-6:10 p.m. Student Ownership of Laboratory Projects and Attitudes about Experimental Physics\***

*Contributed – Dimitri R. Dounas-Frazer, University of Colorado Boulder, Department of Physics 390 UCB, Boulder, CO 80309-0390; dimitri.dounasfrazer@colorado.edu  
H. J. Lewandowski, University of Colorado Boulder*

Multitweek projects in laboratory courses are a promising way to engage undergraduate students in authentic experimental physics practices. In particular, projects provide opportunities for students to take control of an experiment, collaborate with peers or instructors to brainstorm solutions to problems, implement and revise their own ideas, and experience the joys and frustrations of experimentation. Thus, projects are well suited to support two different learning outcomes: developing an understanding of what experimental physics entails, and developing a sense of ownership of a specific experiment. In an ongoing investigation of the impacts of laboratory projects, we are using the Colorado Learning Attitudes About Science Survey for Experimental Physics (E-CLASS) and the Project Ownership Survey (POS) to explore connections between these two learning outcomes. In this presentation, we report results from a multiyear study in which both surveys were administered in an upper-division optics lab that culminated in multitweek projects.

\*This work is supported by the NSF under Grant No. DUE-1726045.

**CA08: 6:10-6:20 p.m. Adapting Measurement and Testing to Integrate Practices within Authentic Contexts**

*Contributed – Anne E. Leak, Rochester Institute of Technology, 84 Lomb Memorial Drive, West Henrietta, NY 14623; aelsps@rit.edu  
Kelly N. Martin, Erik Reiter, Benjamin M. Zwickl, Rochester Institute of Technology  
Abby E. Rocha, Western Illinois University*

While physics educators and researchers value providing students with opportunities to meet a broad range of learning objectives such as concepts, problem solving approaches, and technical skills, it is challenging to accomplish all of these goals. Our research explores the knowledge and skills that make employees successful in physics-intensive careers and suggests strategies for how multiple goals intersect in meaningful learning and workplace contexts based on Berland's "Meaningful Use" framework. We conducted 28 semi-structured interviews with managers and recent hires at optics and photonics companies in Western New York. Our results highlight how testing and measurement integrate multiple learning goals within contexts based on client-driven parameters and constraints. Since testing and measurement are common elements of many physics courses, this research has implications for how we can adapt these activities to meet multiple goals that are meaningful to learning and reflect authentic practice.

**CA09: 6:20-6:30 p.m. Finding Reliable Design Strategies Among Research-based Labs**

*Contributed – Amin Bayat Barooni, Georgia State University, One Park Place, Room 425, Atlanta, GA 30302-3999; abayatbarooni1@student.gsu.edu  
Joshua Von Korff, Georgia State University*

Research-based activities emphasize interactive engagement whereas traditional lab activities ask students to perform procedural steps passively. The objectives and goals of physics instructors who want to create new activities may not be the same as the philosophies of designers who published research-based activities. In this situation, the instructors could combine elements of different activities to create an activity that does respond to their objectives. Our research project aims to assist them in this process. Our research involves analyzing the design strategies used in research-based activities compared to the recent AAPT report on lab design, especially activities used successfully in research. We aim to find reliable codes for characterizing strategies regarding a standard set of design features or a standard taxonomy of functions. We used these codes to classify research-based design activities to make recommendations to instructors about designing activities.

**Session CB: PER: Reasoning, Sensemaking and Modeling**

**Location:** Mount Vernon Square B **Sponsor:** AAPT / PER **Time:** 5–7 p.m. **Date:** Monday, July 30 **President:** Ben Dreyfus

**CB01: 5:00-5:10 p.m. Epistemological Stances and Mathematical Sense Making in Quantum Mechanics**

*Contributed – Jessica R. Hoehn, University of Colorado Boulder, 390 UCB, Boulder, CO 80309; jessica.hoehn@colorado.edu  
Julian D. Gifford, Noah D. Finkelstein, University of Colorado*

Students in our physics courses arrive with, and develop, certain expectations and beliefs about what it means to learn physics and the role of mathematics in learning physics. These epistemological stances may influence the ways in which students engage in problem solving. In this talk, we examine an episode in which a group of students are reasoning about a quantum mechanics problem. We investigate the ways in which students' epistemological stances (both individual and collectively constructed) toward the role of mathematics relate to how they coordinate mathematical formalisms and physical meaning (or how they engage in mathematical sense-making). We discuss potential implications for research and for instruction.

**CB02: 5:10-5:20 p.m. Useful Math: Investigating Mathematical Sense-Making in Learning Quantum Physics**

*Contributed – Julian D. Gifford, University of Colorado Boulder, 1895 Alpine Avenue, Apartment B11, Boulder, CO 80304; Julian.Gifford@colorado.edu  
Jessica R. Hoehn, Noah D. Finkelstein, University of Colorado Boulder*

Coordinating and leveraging mathematical formalisms in order to better understand physical phenomenon -- sometimes called mathematical sense-making (MSM) —can be a powerful way of conceptualizing and analyzing a physical system. Often, this coordination ties together sense-making moves in a more abstract "mathematical" frame (with no necessary connection to the physical system) and relates this abstracted formalism to the physical system of interest. We present data from two groups of Modern Physics students, exemplifying two different scenarios: one in which reasoning in a mathematical frame is productively applied to the physical system of interest (i.e. the coordination between the mathematical formalism and physical system is accurate and leads to a greater understanding of the physical system), and one where it is not. In our analysis, we showcase the conditions and epistemological stances that lead to these different applications of MSM.

**CB03: 5:20-5:30 p.m. Mathematical Sense-making Through Graphical Symbolic Forms\***

Contributed – Erin Ronayne Sohr, University of Maryland College Park, 1322 Toll Physics Building, College Park, MD 20740; erinson@umd.edu

Ayush Gupta, University of Maryland College Park

Andrew Elby, Brandon James Johnson, University of Maryland College Park

Expert as well as novice sense-making with physics equations can be modeled in terms of symbolic forms, cognitive elements in which a conceptual schema (intuitive idea) is associated with a symbolic template (piece of algebraic formalism) (Sherin, 2001). However, experts and students often reason with and about representations other than algebraic equations. By drawing from video-records of undergraduate and graduate students, we extend Sherin's symbolic form framework to a new representational focus—graphs. We show how students associate conceptual meaning with specific graphical features in the context of interpreting or generating graphs during physics problem-solving. We model students' cognition in these moments through "graphical symbolic forms," cognitive elements that have dual membership in conceptual and graphical spaces and show how these are useful for meaning-making. We draw implications for physics education research and instruction.

\*Support: NSF DUE #1625797 Sherin, B. L. (2001). How students understand physics equations. *Cognition and instruction*, 19(4), 479-541.

**CB04: 5:30-5:40 p.m. Modeling Student Equation Construction: Combining Symbolic Forms and Conceptual Blending**

Contributed – Benjamin P. Schermerhorn, University of Maine, University of Maine, 5709 Bennett Hall, Orono, ME 04469; benjamin.schermerhorn@maine.edu

John R. Thompson, University of Maine

Much of physics involves the construction and interpretation of equations. Research on students' mathematics understanding has employed Sherin's symbolic forms or Fauconnier and Turner's conceptual blending as analytical frameworks. However, previous symbolic forms analyses have commonly conflated students' in-context understanding with their conceptual schema, which was designed to represent the acontextual mathematical justification of the symbol template (externalized structure of the expression). Furthermore, conceptual blending analyses have not included a generic space to specify the underlying structure of a math-physics blend. We combine these frameworks in a model for students' construction of equations that uses the conceptual schema as the generic space and that frames the blending of symbol template and conceptual understanding. This combination complements symbolic forms analysis with contextual meaning and provides an underlying structure for the analysis of student understanding of equations. We apply this model to student construction of non-Cartesian differential length vectors.

**CB05: 5:40-5:50 p.m. Inventing with Contrasting Cases to Learn the Concept of Speed**

Contributed – Eric Kuo, University of Pittsburgh, 3939 O'Hara St, LRDC 718, Pittsburgh, PA 15260; erickuo@pitt.edu

Kelly Boden, Quentin King-Shepard, Timothy J. Nokes-Malach, Tanner L. Wallace, University of Pittsburgh

Muhsin Menekse, Purdue University

Inventing with contrasting cases has been shown to help students attend to deep conceptual features of mathematical relations (e.g. Schwartz, Chin, Chase, & Oppenheimer, 2011). We investigated whether inventing a mathematical description for speed from a set of contrasting cases of motion would help students learn its underlying conceptual features. In 6th-grade science classes, inventing-with-contrasting-cases instruction was compared to a standard tell-&-practice approach, where students were told the formula  $s = d/t$  and were given opportunities to apply it. After additional instruction on speed, both instructional groups demonstrated equal success at learning the basic procedure for calculating speed. However, students who invented were better at recognizing the key conceptual features of speed in a new situation where the standard procedure no longer applied. This study shows how students' attempts to characterize a physical quantity on their own can help them to learn the conceptual features of that physical quantity.

**CB06: 5:50-6:00 p.m. PIQL: Physics Inventory of Quantitative Literacy**

Contributed – Suzanne White Brahmia, University of Washington, Department of Physics, Seattle, WA 98195-1560; brahmia@uw.edu

Trevor Smith, Rowan University

Alexis Olsho, University of Washington

Andrew Boudreaux, Western Washington University

Quantitative literacy (QL) is a set of interconnected skills, attitudes and habits of mind that together support the active use of number and numerical reasoning to describe the world. Both everyday sense-making and workplace performance rely on QL, and many K-12 and higher education systems have undertaken systematic attempts to improve student performance bridging the "math world" and "real world." We argue that physics, as perhaps the most fundamental and the most transparently quantitative science discipline, can play a central role in helping students develop quantitative literacy, yet valid measures of such thinking are absent from the growing body of research-based assessment instruments in introductory physics. This talk describes a collaborative effort being undertaken by the UW, RU and WWU to develop tools for the systematic assessment of student quantitative literacy in introductory physics. We share progress made towards creating a PIQL, Physics Inventory of Quantitative Literacy.

**CB07: 6:00-6:10 p.m. Introductory Student Interpretation of Validity Checks of Expressions\***

Contributed – Abolaji R. Akinyemi, University of Maine, Department of Physics and Astronomy, 5709 Bennett Hall, Orono, ME 04469-5709; abolaji.akinyemi@maine.edu

John R. Thompson, University of Maine

One expected student outcome of physics instruction is a set of quantitative reasoning skills that include evaluation of problem solutions, whether expressions or numerical results. We explored students' conceptions of and competence with conducting validity checks by asking how they would check whether an expression for the speed of a block on a ramp with friction was reasonable. Results from 214 written responses and 12 interviews suggest a mismatch between how students framed the task and researchers' expectations. Prevalent approaches included re-deriving the expression from initial conditions or seeking consistency with external sources rather than pursuing an internal, logical consistency. We analyze student approaches through an epistemic games lens, and with evidence from two graduate student interviews, propose a novel game that represents the intended activity and discuss how it is congruent with existing games.

\*Supported in part by NSF Grant PHY-1405726.

**CB08: 6:10-6:20 p.m. Epistemic Modeling Games within Physics-Intensive Workplaces**

Contributed – Benjamin Zwickl, Rochester Institute of Technology, 84 Lomb Memorial Dr., Rochester, NY 14623-5604; ben.zwickl@rit.edu

Dehui Hu, Kingston Chen, Anne E. Leak, Rochester Institute of Technology

Modeling involves linking real-world situations to abstract ideas by developing external representations and using them to explain or predict. Using an epistemic

games framework, we describe features for three games observed in physics workplaces that are rich in modeling and have varied motivations: understanding a natural phenomenon, designing based on customer specifications, and solving a problem in an experiment or process. While each game involves developing and using models to explain or predict, there is a rich diversity among them. In addition to highlighting the variation in starting conditions and end goals of each game, we also identify varied representations (e.g., symbolic math, blueprints), contextual features (e.g., lab environment, customer interactions, software), and particular moves leading between the start and the end. The diversity in workplace modeling games suggests ways to diversify how we approach modeling within the physics curriculum.

**CB09: 6:20-6:30 p.m. Grokking: The Endpoint of Sensemaking**

*Contributed – Tor Odden, 20337 County Road H, Barronett, WI 54813; todden@wisc.edu*

In recent years, physics educators have become increasingly interested in understanding what it means for students to make sense of physics concepts and the ways in which they do so. However, although there has been much discussion of what sensemaking looks like and how it differs from activities like plug-and-chug or answer-making, there has been less discussion of the end-point of sensemaking. In this talk, I aim to introduce a new term to this ongoing discussion, “grokking,” to describe the goal of sensemaking. I will propose a definition for what it means to grok physics based on both historical and contemporary usage of the term, illustrate it with an example from introductory electricity and magnetism, and conclude by describing the importance of this idea for physics educators going forward.

**CB10: 6:30-6:40 p.m. Student’s Perspectives of and Experiences with Sensemaking in Mechanics**

*Contributed – MacKenzie Lenz, Oregon State University, 301 Weniger Hall, Physics Department, Corvallis, OR 97331; lenzm@oregonstate.edu*

*Kelby T. Hahn, Paul J. Emigh, Elizabeth Gire, Oregon State University*

An important instructional goal in physics courses is to help learners develop powerful ways of making sense of physics ideas and problems. We examine the perspectives, experiences, and sensemaking practices of four students enrolled in a post-introductory physics course that explicitly emphasizes sensemaking strategies. Our analysis includes data from homework, exams, a pre-/post- sensemaking assessment, and a series of interviews. Some of the questions we ask include: Do student find sensemaking strategies useful or tedious? How do these views impact the students’ practices? What strategies are they aware of and which do they tend to use? What sensemaking activities do they report doing that are not written down on course assessments?

**CB11: 6:40-6:50 p.m. Thinking Through the Model II**

*Contributed – D. G. Sumith P. Doluweera, Georgia State University, Department of Physics and Astronomy, 1 Park Place, Room 435A, Atlanta, GA 30303; ddoluweera@gsu.edu*

Learning to solve physics problems is a challenging task for a novice physics student because it requires thinking through related models. A particular study done by the author (presented at 2017 summer AAPT meeting) focusing on Newton’s laws and modified multiple choice questions to probe students’ initial thinking showed that majority of students in (both calculus and algebra based) introductory physics courses understand related basic physics concepts. Also it showed that not all of those students are able to use that correct conceptual understanding to obtain correct solution. Further it showed that incorrect concept selection often leads to an incorrect choice of answer. The present study, which is an extension of the previous study, is focused on investigating (I) how conceptual understanding is challenged as the complexity of the problem increases and (II) identifying students’ difficulties of obtaining correct solution. Students’ answers to the selected set of questions are analyzed and results are presented.

**CB12: 6:50-7:00 p.m. Developing Fluency: A Framework for Generating Effective Representations and Tasks**

*Contributed – Rica Sirbaugh French, MiraCosta College & Center for Astronomy Education, One Barnard Drive; Physical Sciences M/S 8C, Oceanside, CA 92056; rfrench@miracosta.edu*

*Edward Prather, University of Arizona & Center for Astronomy Education*

To elevate students’ levels of understanding instructors often actively engage learners with multiple tasks that have been carefully designed and sequenced to build upon their existing knowledge and intuitions. When different intellectual tasks (interpret, visualize, rank, compare, etc.) are connected to pedagogically appropriate representations (words, drawings, graphs, numerical data, vectors, etc.), learners can successfully unpack complex concepts and develop more robust and expert-like understandings. Classrooms that provide a varied and coherent set of tasks and representations afford learners the opportunity for critical discernment and the development of discipline fluency. We present a framework developed to catalog and characterize the representations, tasks, and difficulty levels employed in faculty-produced multiple-choice think-pair-share questions. Additionally we exploit this framework to generate new questions using underutilized components. The framework is easily generalized to many disciplines, instructional materials, and active-learning strategies.

**Session CC: Contributing to, and Using, the IPLS Portal**

**Location:** Marriott Marquis - Magnolia    **Sponsor:** Committee on Physics in Undergraduate Education    **Co-Sponsor:** AAPT    **Time:** 5–7 p.m.    **Date:** Monday, July 30  
**President:** Juan Burciaga

**CC01: 5:00-7:00 p.m. Living Physics Portal: Community and Resources for Physics for Life Sciences**

*Invited – Catherine H. Crouch, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; ccrouch1@swarthmore.edu*

The Living Physics Portal will provide an online platform for sharing and developing curricula for physics for life science students, which will support the formation of a community of developers and implementers. Specifically, it will allow those who are new to such courses to learn about the special features and challenges of teaching such courses from experienced instructors; and it will allow those who develop materials, whether experienced at doing so or novices, to share their materials for feedback at an early stage, or submit them for inclusion in a “vetted collection” for materials that have been extensively used and refined. Finally, it will allow instructors to find materials through a searchable interface providing extensive metadata informing implementation. The Portal is a joint project of AAPT with faculty from eight colleges and universities. This talk will present the overall design of the Portal and the structures to facilitate community formation.

**CC02: 5:00-7:00 p.m. Contributing a Year-Long Introductory Course to the Living Physics Portal**

*Invited – Mark Reeves, George Washington University, Department of Physics, 725 21st St NW, Washington, DC 20052-0001; reevesme@gwu.edu*

Introductory physics for life sciences course instructors commonly profess the goal to instill physics thinking into future physicians and their students wonder why they take physics at all. A primary goal of the Living Physics Portal is to change this thinking. At GW, we have developed a year-long, calculus-based introductory course that is taken primarily by biomedical engineers and mathematically advanced biology students. We have worked with biology faculty and students to develop material that answers a student's question, "What can physics tell me about biology that I cannot learn otherwise?" Our material is being placed on the Living Physics Portal, as is material from similarly focused courses at the Maryland, New Hampshire, and Swarthmore. This talk will focus on our experience in using the portal as contributors at various levels and as users of material placed there by other members of the community.

**CC03: 5:00-7:00 p.m. The Value of Community and Questions that Arise from Portal Submissions**

*Invited – Dawn C. Meredith, University of New Hampshire, 9 Library Way, Durham, NH 03824; dawn.meredith@unh.edu*

The seed contributors to the portal have been testing out the submission process over the last year. I will discuss one such trial submission that came with peer feedback to share the intellectual and emotional challenges and rewards of the process.

**CC04: 5:00-7:00 p.m. The Living Physics Portal and Reforming Introductory Physics for Pre-health Students\***

*Invited – Ralf Widenhorn, Portland State University, SRTC, 1719 SW 10th Ave., Room 134, Department of Physics, Portland, OR 97201; ralfw@pdx.edu*

Physics instruction for life science and pre-health students frequently does not meet students' needs and is often perceived as a weed-out course. A goal of the Living Physics Portal is to let instructors share resources and transform how these students are instructed nationally. Each institution and instructor has different needs, depending on their local student population and infrastructure. At Portland State University the algebra-based physics course is dominated by pre-health students. We are currently in the process of designing a full year sequence that focuses on the needs of these students. For this we worked with biomedical experts on physics content that is authentic to the medical field. This presentation will talk about the challenges of reforming a full year sequence and how the Living Physics Portal can provide a resource to combine one's own instructional material with curriculum that has been successfully used at other institutions.

\*This work was supported by grants DUE-1624192, DUE-1431447, and DUE-1141078 from the National Science Foundation.

**CC05: 5:00-7:00 p.m. The Living Physics Portal Support of Educator Evolution**

*Invited – Nancy Beverly, Mercy College, 555 Broadway, Dobbs Ferry, NY 10522; nbeverly@mercy.edu*

As we evolve as educators, our curricular activities and materials created, or creatively adapted, for our unique curricular environment and life/health science student population, also evolve. When and how to share "works in progress" is addressed in the three-tier submission structure and community building, so evolution is supported by The Living Physics portal at any stage, for a spectrum of user/contributors (users becoming contributors and contributors also being users). Depending on the tier, submitters will be guided to provide potential users with orientation and pedagogy to help transfer usability and adaptability of materials developed for one institutional environment to a variety of other institutional environments. Getting and receiving feedback and proving for further discussion will also play a supportive role.

**Session CD: Exchange of Ideas and Faculty in International Teacher Preparation: Lessons Learned II**

**Location:** Marriott Marquis - Cherry Blossom **Sponsor:** AAPT **Time:** 5-6:10 p.m. **Date:** Monday, July 30 **President:** Dan Maclsaac

**CD01: 5:00-5:30 p.m. Working as a Team: Planning and Teaching a Physics Unit**

*Invited – Bor Gregoric, Uppsala University, Box 516, Uppsala, Non U.S. 75120 Sweden; bor.gregoric@gmail.com*

As a part of their "didactics of physics" course, at Faculty for Mathematics and Physics, University of Ljubljana, Slovenia, students used to visit a local high school to observe and give each a single physics lesson, the topic and form of which depended on the requirements of the teacher hosting them in their classroom. More recently, this model was replaced with a collaborative activity, where all participating pre-service teachers in the course, with the aid of two instructors, together prepare to teach a whole physics unit (e.g. geometrical optics), plan individual lessons, divide the teaching of the lessons among themselves and then teach the unit over the course of a month at a local high school. I will present insights from this reformed practice, as I experienced it as a guest instructor in the fall of 2017.

**CD02: 5:30-6:00 p.m. Physics Teacher Preparation Reform at Hubei University**

*Invited – Weining Wu, Institute of Physics and Electronic Science, Hubei University 368 Youyi Avenue, Wuchang Wuhan, Hubei 430062 China; palmer8888@163.com*

First I will briefly describe physics teacher preparation at the Hubei University in China. There are currently two main problems in the practice of physics teacher preparation in China, one is that the transition periods for newly graduated students to transfer from novices to highly confident and competent teachers are too long; the other is that most teachers are only so called "teacher man," seen as delivering a fixed provided curriculum and know nothing about physics education research. In response to the above problems, at Hubei University, we adopted the following three interventions: a) create conditions to increase the students' practical training time for basic teaching skills; b) on the basis of the traditional curricula, set up elective courses, such as "Research Methods of Physics Education"; and c) encourage and guide students to apply for training programs in innovative research based pedagogy at all levels. Over the past few years, the above measures have achieved good results: Interns' performance in classroom teaching is obviously better than that in the past; the survey reports and theses submitted by students are of higher quality; more students have published articles in official journals, and many have won prizes in various teaching competitions.

**CD03: 6:00-6:10 p.m. Japanese Learning Theory 'HEC' and Its Research Activity**

*Contributed – Koji Tsukamoto, Chiba Institute of Science, 3 Shiomi-cho, Choshi, 2880025 Japan ktsukamoto@cis.ac.jp*

In Japan, the contents of education in primary, middle and high schools are strictly controlled by the government. On the contrary, voluntary research activities by teachers in those schools have been proactive. Japanese scientific learning theory and the Hypothesis Experiment Class (HEC) have also been developed by such teachers. HEC was first advocated by Dr. Itakura, a senior scientist emeritus at the Japanese National Institution for Education in 1963. Then, a lot of results, lesson plans and teaching tools have been reported and discussed in the Association for Studies in Hypothesis-Experiment Class consisting of those voluntary teachers. We



introduce a brief theory of HEC and its research activity in Japan. We believe that while HEC was established in the Japanese educational culture, it could be applicable to all countries around the world.

## Session CE: Exploring Experiments with Augmented Reality

**Location:** Congressional Ballroom A    **Sponsor:** Committee on International Physics Education    **Co-Sponsor:** Committee on Educational Technologies  
**Time:** 5–6:50 p.m.    **Date:** Monday, July 30    **President:** André Bresges

### CE01: 5:00-5:30 p.m. Smartglasses as Assistive Tools for STEM Laboratory Courses – Technical Aspects

*Invited – Martin P. Strzys, TU Kaiserslautern, Erwin-Schrödinger-Str. 46, Kaiserslautern, RP D-67663 Germany strzys@physik.uni-kl.de  
Michael Thees, Sebastian Kapp, Pascal Klein, Jochen Kuhn, TU Kaiserslautern*

Augmented reality (AR) learning environments are scenarios in which virtual digital augmentations and real-world objects coexist and are able to interact with each other. As learners are able to manipulate both simultaneously, digital augmentations can be integrated into laboratory experiments to achieve different goals: provide interaction elements to control the experimental setup, visualize experimental data in real-time using various representations, display tutorials or explanations. In this contribution we focus on AR scenarios realized with the help of smartglasses. We show how experimental setups can be enhanced with such a technology and how external sensors can be used to collect experimental data of abstract physical quantities like temperature or voltage, which can then be presented directly in the learner's field of view using suitable representations. Moreover, we discuss the technical requirements and affordances for a beneficial use in laboratory courses.

### CE02: 5:30-6:00 p.m. Smartglasses as Assistive Tools for STEM Laboratory Courses - Theoretical Foundations

*Invited – Michael Thees, Technische Universität Kaiserslautern, Erwin-Schroedinger-Straße, Kaiserslautern, RLP 67663 GERMANY theesm@physik.uni-kl.de  
Martin Peter Strzys, Sebastian Kapp, Klein Pascal, Jochen Kuhn, Technische Universität Kaiserslautern, Kaiserslautern, Germany*

Realizing augmented reality (AR) learning scenarios with see-through smartglasses creates a wearable educational technology providing active access to various additional information without distracting from the physical interaction with the reality. By displaying information directly in the user's field of view, the combination of real world and virtual objects creates a learning environment that enables students to evaluate their own measurements in more detail, to draw conclusions for further investigations or functional correlations between physical quantities. In this contribution, we apply the theoretical framework of multimedia learning to AR scenarios in introductory STEM laboratories, resulting in positive hypotheses about students' learning and motivation. Based on major principles of the Cognitive-affective theory of learning with media (spatial and temporal contiguity), this tool can (a) provide a real-time feedback while sustaining students' autonomy and authenticity of action, (b) structure students' hands-on experiences, and (c) guide their attention to cue points of knowledge construction.

### CE03: 6:00-6:30 p.m. AR with Smartphones and Tablets as Pocket-Labs

*Invited – Jochen Kuhn, TU Kaiserslautern, Dept. of Physics/Physics Education Research Group, Erwin-Schrödinger-Str. 46, Kaiserslautern, Rhineland-Palatinate 67663 kuhn@physik.uni-kl.de*

*Pascal Klein, Michael Thees, Sebastian Becker, TU Kaiserslautern, Dept. of Physics/Physics Education Research Group*

Smartphones and tablets can be used as experimental tools especially in physics classrooms. This is possible because today's smartphones and tablets are equipped with many sensors, which can be used to perform quantitative and qualitative experiments. These mobile devices could be used as mobile "labs in your pocket" (so called Pocket-Labs) throughout various topics by students in high school and introductory physics courses and could so augment learning with experiments by providing respective data. In this talk, we integrate learning with smartphone and tablets as Pocket-Labs in the context of AR and present a survey of examples using smartphone and tablets as experimental tools related to different topics in physics classrooms and in introductory physics courses. Finally an overview of the results of studies with quasi-experimental treatment-control group design will be presented and their results will be discussed.

### CE04: 6:30-6:40 p.m. Collaborative Exploration of Introductory E&M via Augmented Reality

*Contributed – Steven Binz, Salisbury University, 1101 Camden Ave., Salisbury, MD 21801; smbinz@salisbury.edu*

Augmented reality places computer-generated content into the field of view of the user and until recently, this meant the content was added to a video feed that would then be displayed on a computer. Now there are general-purpose headsets that can be worn that make it look like the graphics are in the room with the user, who can then walk around and interact with them in an intuitive way. I am using this technology to help students learn about electric and magnetic fields by developing a program that allows students to collaboratively create and move simulated charges so they can see the interaction between the fields and the charges. The goal is for student comprehension to improve when they can interact with each other while using the simulation and can see the fields and forces in all three dimensions.

### CE05: 6:40-6:50 p.m. Virtual Reality as a Teaching Tool for Moon Phases and Beyond

*Contributed – Jack Madden, Cornell University, Space Sciences Room 514, Ithaca, NY 14850; jhm355@cornell.edu*

*Natasha Holmes, Andrea Stevenson Won, Jonathon Schuldt, Cornell University*

A ball on a stick, a common and simple demo for teaching the phases of the Moon. This demo, like many others in physics and astronomy, gives students a perspective they otherwise could only imagine. For Moon phases, a third person view and control over time allows students to rapidly build a mental model that connects all the moving parts. Computer simulations of many traditional physics and astronomy demos provide new features, controls, or vantage points to enhance learning beyond a hands-on demo. Virtual reality provides the capabilities of computer simulations and the embodied cognition of a hands-on experience making it a natural step to improve learning. We recreated the traditional ball-and-stick moon phases demo in virtual reality and compare the learning gains using this simulation with those using traditional methods. Our study will inform on the benefits and compromises to be had using virtual reality as a teaching tool.

## Session CF: K-12 PER

Location: Marriott Marquis - Scarlet Oak

Sponsor: Committee on Physics in High Schools Co-Sponsor: Committee on Research in Physics Education

Time: 5-7 p.m. Date: Monday, July 30

President: Dan Crowe

### CF01: 5:00-5:30 p.m. Organizing Physics Teacher Professional Education Around Productive Habit Development

Invited – Stamatis Vokos, Cal Poly San Luis Obispo, 1 Grand Ave., San Luis Obispo, CA 93407; svokos@calpoly.edu

Eugenia Etkina, Rutgers University

Bor Gregorcic, Uppsala University

Let us stipulate that physics teacher education programs have shared views as to the requisite dispositions, knowledge, and skills needed for effective teaching. However, even if these are developed, the professional demands on a teacher's time are so great out of, and so complex during class time that if every decision requires multiple considerations and deliberations with oneself, the productive decisions might not materialize. We argue that the link between intentional decision making and actual teaching practice are teachers' habits. In this talk, we provide a theoretical framework for the determinative role that habits of mind, habits of practice, and habits of maintenance can play in teacher formation and professional growth. The indispensable context for habit development is apprenticeship in a community that shares a common vision for effective teaching. Some implications of this framework will be presented, as well as possible future research agendas around habits.

### CF02: 5:30-6:00 p.m. Assessing the Impact of a Game-Centered, Interactive Approach for Using Programming Exercises in Introductory Physics

Invited – Chris Orban, The Ohio State Univ at Marion, 1465 Mt. Vernon Ave., Marion, OH 43302; orban@physics.osu.edu

Richelle Teeling-Smith, University of Mt. Union

Computer programming is an increasingly desired skill for all STEM fields, not just computer science. We created simple and interactive computer programming activities based on the physics of video games and integrated these into introductory physics classes. Importantly, these activities typically involve less than 75 lines of code. Students completed an online assessment before and after each activity to measure the students' comprehension of physics concepts through a variety of animated questions and to gauge student perceptions about the activity, such as difficulty, level of enjoyment and whether it changes their attitudes about STEM. Data have been collected from introductory physics courses at local high schools and two different universities.

### CF03: 6:00-6:10 p.m. Designing NGSS Aligned Single/Multiple Select Assessment Tasks

Contributed – Debbie S. Andres, Paramus High School, 99 East Century Road, Paramus, NJ 07652; dandres@paramusschools.org

The Next Generation Science Standards (NGSS) call for a three-dimensional approach to learning. Within high school classrooms, students engage in hands-on investigations, discussions, and written activities. Teachers use a variety of formative and summative assessment techniques to measure student proficiency. In New Jersey, the adoption of NGSS has necessitated change at the state assessment level. What does an assessment question that addresses all three dimensions of NGSS look like? During the 2017-2018 school year, I had the opportunity to work on district and statewide committees focused on the development of three-dimensional assessment tasks. In this talk, I will share several examples of, and strategies for, the creation of single/multiple select assessment tasks. Each assessment task addresses a phenomena and uses the three dimensions of NGSS to effectively evaluate student proficiency.

### CF04: 6:10-6:20 p.m. Creating Student Agency Using NGSS Science Practices in Physics Classroom

Contributed – Nicole B. Schrode, St. Vrain Valley School District and University of Colorado, 227 Sunland St., Louisville, CO 80027; schrode\_nicole@svvsd.org

Rebecca Stober, Mapleton Public Schools and University of Colorado

The NGSS aligned Physics and Everyday Thinking High School (PET-HS) curriculum engages students in science practices of generating and defending claims using evidence as a means of developing and formalizing physics principles. This study focuses on how students typically underrepresented in traditional physics classes respond to the PET-HS curriculum as compared to a matched sample using other types of curricula. Students in both settings took a peer-created, conceptual diagnostic exam at the beginning and end of the year and growth was calculated. Preliminary findings suggest that students within the PET-HS classrooms from underrepresented groups show no significant difference in learning gains compared to students in majority groups. Additionally the PET-HS students demonstrated significantly higher effect size than those within the matched sample classrooms. We will discuss structures and practices that seem to facilitate a learning environment where all students are able to access scientific principles and practices.

### CF05: 6:20-6:30 p.m. Impact of Online Inquiry-based Physics Courses on Student Achievement

Contributed – Marie Hamaoui, OHS Stanford University, 220 Panama St., Stanford, CA 94305; mhamaoui@stanford.edu

Alexander McKale, OHS Stanford University

Gary Oas, OHS Stanford University

We are performing a study comparing the achievement of online honors physics students who took an online, inquiry-based physics course in middle school with those who did not. The specially designed, inquiry-based physics, online course was structured to cultivate a middle schooler's physics intuition and lay a foundational groundwork often assumed in later courses. Using anonymized student data, we will run a MANCOVA to determine any statistical differences in the students' achievements. We will also discuss the advantages of our online preparatory course and the online honors physics environment.

### CF06: 6:30-6:40 p.m. Preparing Students for Long-Term Open Inquiry Projects – Students' Perspective

Contributed – David Perl, \* Weizmann Institute of Science, 27 Weizmann St., Rehovot, Rehovot 7628207 Israel; davidperl6@gmail.com

Edit Yerushalmi, Weizmann Institute of Science

The advanced high-school physics course is commonly directed towards a high-stake exam. A three-year course, titled INQUIRY-PHYSICS, takes place in Israeli education system as an addition to the traditional physics course. It intends to bypass the difficulty of integrating open ended inquiry activities into test oriented setting. This timeframe allows for a gradual learning progression, developing inquiry practices in contexts that span from 1-2 lessons to a yearlong research project. I will describe the findings of an artifact-based interview that took place few months after the students launched their work on the research project. Student were asked to identify inquiry practices they have encountered earlier in the course and reflect on their fruitfulness. In particular, which of these practices they perceive as crucial to experience before engaging in a long term project. I will discuss these findings in view of the learning goals and design principles of the teachers.

\*Sponsored by Edit Yerushalmi

**CF07: 6:40-6:50 p.m. Investigating Differences in How Physics and Biology Model Energy Flow\***

*Contributed – Michael C. Wittmann, University of Maine, 5709 Bennett Hall, Orono, ME 04469-5709; mwittmann@maine.edu*

*Troy Whitaker, University of Maine*

In Energy Theater, people represent units of energy and locations on the floor represent objects in the system. Movement of people therefore represents the flow of energy. Biology teachers participating in a professional development activity enacted the flow of energy in an ecosystem and afterwards discussed the ways in which Energy Theater led to the modeling of ideas that are not usually discussed in biology classrooms. For example, issues of energy conservation and thermal dissipation were typically not of importance to them, but required within the modeling activity. Our work shows some of the ways that physicists and biologists teach and discuss the NGSS crosscutting concept of energy flow differently. Our work also points out that there are productive and hopefully simple ways for teachers to talk across disciplines in ways that helps students learn the crosscutting concepts of energy flow more effectively.

\*Sponsored in part by NSF grants 0962805 and 1222580.

**CF08: 6:50-7:00 p.m. Engaging School Students with Open Inquiry Investigations via Digital Technologies**

*Contributed – Srividya Durga Kota, The University of Sydney, School of Physics, Camperdown, NSW 2006; skot2539@uni.sydney.edu.au*

*Scott Cornish, Manjula Devi Sharma, The University of Sydney*

Can digital technologies be harnessed to engage students with open inquiry, or would they make it more challenging? This paper reports on an investigation on electricity—‘Vampire Power’. Using Design-Based Research methodology, Trial 1 was open inquiry, Trial 2 included digital technologies, Excel spreadsheet and Trial 3 was final deployment. Trial 1 ran with 41 teachers and 58 students in 4 workshops, Trial 2 with 25 teachers and 38 students in 2 workshops and Trial 3 with 29 teachers and 85 students in 3 workshops. Measures of ‘mental effort’ and ‘attitudes’ indicated that, in Trial 1, while teachers invested mental effort and had positive attitudes, students did not. In Trial 2, both teachers and students invested mental effort and had positive attitudes. Trial 3 results were similar to Trial 2. We conclude that, in this case, the integration of digital technologies into an open inquiry investigation improved student engagement.

**Session CG: Lessons Learned in the Robert Noyce Scholarship Program: Winning and Servicing the Grant**

**Location:** Marriott Marquis - Silver Linden    **Sponsor:** Committee on Teacher Preparation    **Time:** 5–6:30 p.m.    **Date:** Monday, July 30    **President:** Gay Stewart

**CG01: 5:00-5:30 p.m. Winning a Robert Noyce Scholarship Grant**

*Invited – John Stewart, West Virginia University, 135 Willey St. Morgantown, WV 26506; jcstewart1@mail.wvu.edu*

The Robert Noyce Scholarship program provides substantial funding to support scholarships for STEM graduates who plan to teach in high need classrooms. The scholarships can attract new students to teaching or retain students by providing bridge funding if obtaining a teacher certification requires more than four years. The author has been PI on two successful Noyce proposals (and two unsuccessful) and will share the lessons learned about crafting a successful Noyce proposal. Topics discussed will include capacity, recruiting, cohort building, programmatic quality, partnerships, and research. A Noyce scholarship program can be invaluable to successfully implementing or growing an undergraduate teacher preparation program. It can also allow STEM graduates to pursue post baccalaureate programs when no undergraduate program is available or when they make the decision to teach too late to enter the undergraduate program.

**CG02: 5:30-6:00 p.m. Recruiting and Retaining Teachers from a STEM-focused University**

*Invited – Kristine E. Callan, Colorado School of Mines, 1500 Illinois St., Golden, CO 80401; kcallan@mines.edu*

*Wendy K. Adams, Colorado School of Mines*

About a year after we enrolled our first Colorado School of Mines students in our newly formed teacher preparation program, we won a Robert Noyce Scholarship Grant to help us prepare more highly qualified science and math teachers. We are now finishing our second year of the grant and have learned a few lessons along the way: 1) We need to address perceptions (many of which are Misperceptions) about the teaching profession with students and faculty early and often; 2) Coupling paid Noyce Internships with an early field experience course and work-study can create an efficient recruiting and prestige-building mechanism; and 3) There are certain types of retention issues that Noyce Scholarships alone will not fix.

**CG03: 6:00-6:30 p.m. Preparing Your Noyce Grant for Continued Success Upon Official Completion**

*Invited – David Rosengrant, University of South Florida St. Petersburg, 140 7th Avenue South, Coquina 201, Bradenton, FL 34212; rosengrant@mail.usf.edu*

*Samuel J. Polizzi, Michelle Head, Kennesaw State University*

*Gregory Rushton, Stony Brook University*

*Brett Criswell, University of Kentucky*

Many funding programs, including Noyce, require the project team to address the issue of sustainability. Seeking new grant funding is an obvious option, but often difficult to guarantee. We propose there are multiple strategies a project can implement while it is funded to prepare for successful completion and sustainability. The authors are all part of the leadership team of a large multi-year Robert Noyce Grant at Kennesaw State University. We recently completed the bulk of this grant and are now working with the participants who are no longer funded nor required to be part of the project. In this talk, we will discuss aspects of our conceptual framework and our project’s design features that we believe has influenced its sustainability. In particular, we will highlight what has and has not worked in keeping the participants actively engaged in the ideals of this project.

## Session CH: Panel – NSF ADVANCE Program

**Location:** Marriott Marquis - Tulip    **Sponsor:** Committee on Women in Physics    **Co-Sponsor:** Committee on Professional Concerns    **Time:** 5–6:30 p.m.  
**Date:** Monday, July 30    **Presenter:** Anne Cox

*Panelists will share their perspective on the NSF Advance Program beginning with the view from the Program Director, followed by a co-PI on an ADVANCE project and then current participants in the eAlliance ADVANCE program administered through AAPT. Come and learn about opportunities for women science faculty, the ways in which the National Science Foundation is helping to advance the careers of women scientists in academia and AAPT's current work to support the development of women physicists.*

### Speakers:

Jessie DeAro, Program Director, NSF Advance Program National Science Foundation  
Ashley Carter, Amherst College  
Sarah Johnson, Shrum Science Simon Fraser University, BC Canada  
Merideth Ann Frey, Sarah Lawrence College  
Cindy Blaha, Carleton College

## Session CI: Peer Review and the Peer Review Process

**Location:** Meeting Room 2    **Sponsor:** AAPT    **Time:** 5–6:30 p.m.    **Date:** Monday, July 30    **Presenter:** Joseph Kozminski

### CI01: 5:00-5:30 p.m. Expectations and Characteristics of the Peer Review of Grant Applications

*Invited – Stephen A. Gallo,\* American Institute of Biological Sciences 1313 Dolley Madison Blvd. Suite 402, McLean, VA 22101-3926; sgallo@aibs.org*

Despite its use to direct billions of dollars in research funds, there is little data-based analysis in the literature regarding the peer review of grant applications. While most would agree that expectations for the process include effective and unbiased decision making, it is surprising that many operational characteristics have not been documented in sufficient detail and it is unclear whether the process is living up to expectations. In an effort to address this need, the American Institute of Biological Sciences (AIBS) has conducted a series of retrospective analyses of data from thousands of peer reviewed applications as well as conducted surveys of both applicants and reviewers. In these analyses, we have examined characteristics of the peer review process (including reviewer expertise, levels of reviewer participation, virtual versus onsite interaction, perceptions of criteria usage, and levels of conflict of interest) and how they relate to the expectations for peer review.

\*Sponsored by Mel Sabella

### CI02: 5:30-6:00 p.m. National Science Foundation's Merit Review Process

*Invited – Corby Hovis, National Science Foundation, 2415 Eisenhower Ave., Alexandria, VA 22314; chovis@nsf.gov*

The National Science Foundation's approach to peer review is often cited as the "gold standard" for evaluating research proposals and has been used as a model by other grant-making organizations. The presenter will provide an overview of NSF's merit review process and criteria, with attention to their historical development and their practical application in the making of funding decisions.

### CI03: 6:00-6:30 p.m. The Congressional Politics of Peer Review

*Invited – Mitch Ambrose,\* American Institute of Physics, 1 Physics Ellipse, College Park, MD 20740-3841; mambrose@aip.org*

The criteria that federal science agencies use to allocate grant funding have periodically attracted scrutiny by members of Congress. My presentation will summarize contemporary congressional debates about the peer review process, focusing on the National Science Foundation. In particular, I will discuss recent legislative proposals to modify NSF's grant review criteria.

\*Sponsored by Mel Sabella

## Session CJ: PTR A: Model Gravitation Waves in YOUR Classroom

**Location:** Meeting Room 3    **Sponsor:** Committee on Physics in High Schools    **Time:** 5–6:30 p.m.    **Date:** Monday, July 30  
**Presiders:** Karen Jo Matsler and Tommi Holsenbeck

*Seems like a science fiction movie, but gravitational waves have been detected and students are curious as to how we know they are "for real." This workshop is based on resources developed by the Perimeter Institute and introduces students to some of the key concepts behind gravitational waves to help build up student understanding of this cutting-edge topic. Topics include how does mass warp space, how does a gravitational wave effect space, and how does LIGO work? Materials necessary to complete the activities will be provided to participants.*

## Session CK: The Art and Science of Teaching

Location: Marriott Marquis - Chinatown Sponsor: Committee on Physics in Undergraduate Education Time: 5–6:30 p.m. Date: Monday, July 30 President: Andy Gavrin

### CK01: 5:00-5:30 p.m. Professional Development for Research; Research on Professional Development

Invited – Eleanor C. Sayre, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506; esayre@gmail.com

Scott V. Franklin, Rochester Institute of Technology

Mary Bridget Kustus, DePaul University

The art and science of teaching is bound up in the art and science of research; we are better teachers for being researchers, and better researchers for being teachers. Usually when we talk about faculty professional development, we mean helping faculty become better teachers. How do faculty become better researchers? How might we enable DBER-adjacent faculty and solo faculty to engage with research as co-creators instead of consumers? For the last five years, we have been building professional development models for emerging, established, and isolated education researchers. Our community-based, collaborative field schools cover theories and methods; research ethics; framing and submitting papers; mentoring undergrads in research; and the messy practicalities of becoming more research-y in your practice. In this talk, I'll outline our evolving model for professional development as well as some of the research which has emerged from our field schools.

### CK02: 5:30-6:00 p.m. Using Theory to Inform Practice in the Physics Classroom

Invited – Ramon E. Lopez, The University of Texas at Arlington, Department of Physics, Arlington, TX 76019; relopez@uta.edu

There is a famed aphorism (incorrectly attributed to Yogi Berra) that observes “In theory, theory and practice are the same. In practice they are different.” This statement applies well when one considers the application of results from physics education research (theory) to classroom instruction (practice). The boundary layer between the two, through which they communicate and inform each other, is the art of teaching. One clear example of this is the strong research evidence in favor of active learning environments. But taking that theoretical basis and creating and engaging classroom will vary greatly from person to person and class to class. In this presentation I will present several examples of how I have applied research-based techniques to classroom instruction at a variety of levels, and how the specifics of the student audience have resulted in modifications of the theoretical approach.

### CK03: 6:00-6:30 p.m. Rainbows, Zealots and the Importance of Student Storytelling

Invited – Gary D. White, AAPT and GWU, Department of Physics, The George Washington University, Washington, DC 20052-0001; gwhite@gwu.edu

Sporting a prodigious swirl of hair, black and shiny as a brand new physics lab table, Ms. McKeithen quietly began dismantling my oft-proclaimed hatred of “language arts” with lessons on poetry that started with music (think Redding, Joplin, McLean, etc.). She often drew upon our passion regarding the injustices inflicted upon teens in an adult world, propelling us to write our stories with unprecedented fervor, and occasionally, to consider the larger universe beyond rural Louisiana. Months later, I could no longer say that I hated language arts, even in jest. Was she an artist? Undoubtedly. Most importantly, she incentivized us to tell our tales, to become our more authentic selves through our own storytelling, even inviting us to re-invent ourselves through our creations. I will relay more about her artistry, connecting it to a certain zealotry for injecting science and storytelling into physics teaching, and invoking literal and metaphorical rainbows.

## Session CL: The Latest & Greatest Electronic Resources from the AAPT and How to Access Them on the Web

Location: Meeting Room 5 Sponsor: Committee on Educational Technologies Time: 5–7 p.m. Date: Monday, July 30 President: Larry Engelhardt

### CL01: 5:00-7:00 p.m. AAPT Digi Kits

Invited – Caroline Hall, American Association of Physics Teachers, One Physics Ellipse, College Park, MD 20740; chall@aapt.org

View and interact with one of the AAPT's newest publications: Digi Kits for teaching and learning physics in secondary classrooms. Digi Kits are interdisciplinary multimedia collections inspired by articles in *The Physics Teacher*. In this session, discover how you can use Digi Kits to support cross-curricular units, incorporate modeling and engineering design with AAPT-approved digital resources, and introduce inexpensive investigations that are explicitly aligned with NGSS content standards for high school. Digi Kits are available at no extra cost to AAPT members.

### CL02: 5:00-7:00 p.m. Living Physics Portal: An Online Resource for Sharing and Support\*

Invited – Edward F. Redish, University of Maryland, Department of Physics, College Park, MD 20742-4111; redish@umd.edu

Chandra Turpen, University of Maryland

Sarah McKagan, Adrian Madsen, AAPT

The Living Physics Portal is a new web resource created by AAPT and faculty from eight colleges and universities, where physics educators can share and discuss curricular materials for teaching introductory physics for life science students (IPLS). The portal will make it easy for educators to: (1) find relevant IPLS curricular resources for all or part of a course, (2) contribute and review curricular resources, (3) adapt and organize materials for their own course, and (4) participate in discussions about instructional innovations and teaching dilemmas relevant to IPLS courses.

\*Supported in part by NSF grant DUE-16-24478

### CL03: 5:00-7:00 p.m. PhysPort: Supporting Physics Teaching with Research-based Resources

Invited – Sarah B. McKagan, American Association of Physics Teachers, 124 28th Ave., Seattle, WA 98122; sam.mckagan@gmail.com

Adrian M. Madsen, American Association of Physics Teachers

Eleanor C. Sayre, Kansas State University

Physics education researchers have created research results, teaching methods, curricula, and assessments that can dramatically improve physics education. PhysPort ([www.physport.org](http://www.physport.org)) is the go-to place for ordinary physics faculty to find resources for research-based teaching and assessment. PhysPort includes overviews of over 50 research-based teaching methods and over 80 research-based assessment instruments, Expert Recommendations, the Virtual New Faculty Workshop, the

Periscope collection of video-based TA training and faculty professional development materials, and the Assessment Data Explorer, an interactive tool for faculty to get instant analysis and visualization of their students' responses to research-based assessment instruments including the FCI, BEMA, and CLASS, and compare their results to national averages. The development of PhysPort includes research to determine faculty needs and usability testing to ensure that we meet those needs.

#### **CL04: 5:00-7:00 p.m. The Partnership for Integration of Computation into Undergraduate Physics**

*Invited – Walter Freeman, Syracuse University, 215 Physics Building, Syracuse, NY 13244; wafreema@syr.edu*

PICUP is best known for its collection of computational exercise sets that can be adapted to any physics classroom, but the collaboration can offer much more than that. We are a loose collaboration of instructors who believe that numerical calculations are a wonderful adjunct to analytical mathematics as a means for students to grow as physicists, and exist to build a community to support all physics instructors in their use of computation in the classroom.

#### **CL05: 5:00-7:00 p.m. ALPhA's Electronic Resources for Teaching Experimental Physics**

*Invited – Elizabeth George, Wittenberg University, PO Box 720, Springfield, OH 45501; egeorge@wittenberg.edu*

Are you teaching an upper-level lab course for the first time? Revising an existing lab course? Looking to add some experimental elements to a theoretically or computationally focused course? The advanced laboratory community has many excellent online resources for you. These resources include innovative experiments and activities, student-tested lab manuals, and effective approaches to teaching and assessing important skills such as uncertainty analysis and technical writing. Many of these materials have been collected from conferences and workshops sponsored by the Advanced Laboratory Physics Association (ALPhA), an association of faculty and staff dedicated to enhancing experimental physics instruction. Come learn about available resources and try some of the activities.

#### **Session CM: Panel – 30 Demos in 60 Minutes**

**Location:** Marriott Marquis - Dogwood    **Sponsor:** Committee on Teacher Preparation    **Co-Sponsor:** Committee on Physics in High Schools    **Time:** 5:30–6:30 p.m.  
**Date:** Monday, July 30    **Presenter:** Wendy Adams

*Our panel of physics teachers will present at least 30 dynamic demonstrations that will engage students in the wonder of science. Presenters will share tips on the setup, materials, procedure, and underlying science concepts so the audience can integrate these demos into their own classrooms.*

#### **Session Poster Session 1**

**Location:** Grand Ballroom South    **Time:** 8:30–10 p.m.  
**Date:** Monday, July 30

Persons with odd-numbered posters will present their posters from 8:30 to 9:15 p.m.; those with even-numbered posters will present from 9:15 to 10 p.m. Posters will be available until 10 p.m.

## **Astronomy**

#### **PST1A01: 8:30-9:15 p.m. Teaching Seasons When Distance Does Matter**

*Poster – Mary M. Brewer Sherer, William Jewell College, 500 College Hill, Liberty, MO 64068; brewerm@william.jewell.edu*

When teaching the cause of the seasons on Earth, the main misconception is that the distance changes from the Sun dictate the seasons. Multiple studies and teaching lessons have been developed to help dispel this misconception. In my astronomy and astrobiology courses, most students can correctly identify the cause of the seasons on Earth, but when trying to apply this framework to extra-solar planets, their gaps in deep understanding show. Many extra-solar planets have such elliptical orbits that the distance from their star does cause seasons, yet students do not always have the tools available to decide which factors are important. Through a light sensor and an Arduino, I have developed a lab that allows students to vary both the angle of the light and the distance to understand how much each affect the radiation at a planet's surface.

#### **PST1A02: 9:15-10:00 p.m. The Impact Crater at Middlesboro, KY**

*Poster – Bob Powell, University of West Georgia, Carrollton, GA 30118; bpowell@westga.edu*

*Ben Jenkins, University of West Georgia*

The authors visited the astrobleme at Middlesboro, KY, on their way home after S17 meeting of AAPT at Cincinnati, OH. The Middlesboro crater is 4.8 km in diameter and was formed less than 300 million years ago. Its identification as an impact site was confirmed in 1966 when Robert Dietz discovered shatter cones in sandstone; shocked quartz was later found. Early travelers, including Daniel Boone, found the relatively flat basin easy to travel after crossing the Cumberland Gap. The authors visited the town's exhibit about the event and photographed the circular form from Pinnacle Overlook in the nearby mountains.

#### **PST1A03: 8:30-9:15 p.m. The Niels Bohr Institute Youth Lab Exoplanet Mystery Box**

*Poster – Ian Bearden, Niels Bohr Institute, Blegdamsvej 17, Copenhagen, 2100 Denmark bearden@nbi.dk*

*Marta Mrozowska, Jo Verwohlt, Axel Boisen, Jimmy C. Hansen, Niels Bohr Institute*

We have developed an Arduino controlled, 3D printed orrery, which, when observed with a photosensor (the light sensor on an IOLab, for example) can be used to illustrate how exoplanets are detected using the transit method. Each orrery has two "orbits" with interchangeable planets so that students can investigate the relationship between planet size and transmitted light from the "star" which they orbit. In our model, the "star" is a large light bulb. After students become familiar with this simple system, they take data from an orrery (hidden in the mystery box) which has an unknown number of planets of unknown size. When the students finish analyzing these data, the mystery box is opened and the results compared with the now visible model.

**PST1A04: 9:15-10:00 p.m. Building a Radio Telescope after ALPhA Immersion Experience**

Poster – Erin De Pree, St. Mary's College of Maryland, 47645 College Dr., St. Mary's City, MD 20686; ekdepree@smcm.edu

Constructing a small radio telescope for our advanced lab course has led to unexpected benefits. In addition to offering several students research and construction experience, the machining skills developed are leading to a new course on metalworking for instrument making. We will discuss the unexpected challenges of learning metal machining skills from scratch, integrating multiple sets of instructions and notes, and the progress to date. The telescope is currently on schedule to join the experimental line up in our advanced lab course in the spring 2019 semester. We will also publish a complete instruction manual later in 2019. The telescope was originally designed by Alan Rogers at MIT's Haystack Observatory and modified by Carl Akerlof at the University of Michigan. The Advanced Laboratory Physics Association (ALPhA) immersion course in summer 2016 led by Carl Akerlof made this project possible.

**PST1A05: 8:30-9:15 p.m. Evaluation of an Interactive Undergraduate Cosmology Curriculum\***

Poster – Kimberly Coble, San Francisco State University, 1600 Holloway Ave., Dept. of Physics & Astronomy, TH 334, San Francisco, CA 94132-1740; kcoble@sfsu.edu

Aaron White, San Francisco State University

Dominique Martin, Patrycia Hayes, Chicago State University

Lynn R. Cominsky, Tom Targett, Sonoma State University

The Big Ideas in Cosmology is an immersive set of web-based learning modules that integrates text, figures, and visualizations with short and long interactive tasks as well as labs that allow students to manipulate and analyze real cosmological data. This enables the transformation of general education astronomy and cosmology classes from primarily lecture and book-based courses to a format that builds important STEM skills, while engaging those outside the field with modern discoveries and a more realistic sense of practices and tools used by professional astronomers. Over two semesters, we field-tested the curriculum in general education cosmology classes at a state university in California [N ~ 80]. We administered pre- and post-instruction multiple-choice and open-ended content surveys as well as the CLASS, to gauge the effectiveness of the course and modules. Questions addressed included the structure, composition, and evolution of the universe, including students' reasoning and "how we know."

\*Funding acknowledgements Module development and evaluation was supported by NASA ROSES E/PO Grant #NNX10AC89G, the Illinois Space Grant Consortium, the Fermi E/PO program, Sonoma State University's Space Science Education and Public Outreach Group, and San Francisco State University. The modules are published by Great River Learning/Kendall-Hunt.

## Labs/Apparatus

**PST1B01: 8:30-9:15 p.m. London Lab Group**

Poster – Scott Dudley, TISIS England, Coldharbour Lane, Thorpe, Surrey TW20 8TE United Kingdom sdudley@tasisengland.org

This poster provides an update on the effort to form a laboratory users group among local physics teachers. One key aspect of the effort were funds provided by a Bauder Grant which allowed the distribution of IOLab devices across the group.

**PST1B02: 9:15-10:00 p.m. Muon Telescopes for First Year Physics Students**

Poster – Ian G. Bearden, Niels Bohr Institute, Blegdamsvej 17, Copenhagen, 2100 Denmark bearden@nbi.dk

We have had a number of students build muon telescopes based on both GM tubes and scintillators for their quasi-independent first year research projects. This poster will summarize our experiences with such projects. Possible designs for and preliminary results from a muon detector inexpensive enough that it is possible to procure a "class set" for introductory relativity labs will also be presented. Finally, we discuss how one could incorporate the building of such detectors in the advanced lab for use in introductory labs.

**PST1B03: 8:30-9:15 p.m. Physiological Response of Localized Cooling of the Skin Recorded by Thermal Imaging**

Poster – Haraldur Audunsson, Reykjavik University, Menntavegur 1, Reykjavik, Reykjavik 1010 Iceland; haraldura@ru.is

Lilja B. Indridadottir, Reykjavik University

The use of thermal imaging to demonstrate some basic principles of physics is becoming a common practice in introductory physics courses. This is in part stimulated by greater access to thermal cameras, due to lower cost, ease of use, and by the increasing number of potential demonstrations. However, applications of thermal imaging in exploring human physiology and consequent quantitative modelling do not appear to be as many. In our poster we will give one example of using thermal imaging to observe the physiological response after localized cooling of the skin on the forearm. The thermal images provide data for quantitative mapping of the local physiological thermal response, which can be used to engage students in constructing simple numerical models for both the lateral scale of the stimulation and a response time.

**PST1B04: 9:15-10:00 p.m. Rigorous At-Home Experiments with the IOLab for Introductory E&M**

Poster – Shawn A. Weatherford, University of Florida, 2001 Museum Drive, Gainesville, FL 32611-9500; sweatherford@ufl.edu

Robert DeSerio, University of Florida

Introductory physics experiments for the online learner have been designed to be performed at home with an aim towards achieving student outcomes comparable to those from traditional on-campus laboratories. This presentation features selected at-home experiments piloted for the initial offering of an algebra-based introductory physics laboratory course focusing on electricity, magnetism, and optics for UF Online, a program providing fully online bachelor degrees. Utilizing the IOLab, a wireless dynamics cart with a suite of onboard sensors suitable for investigating physics principles with a laptop, paired with a custom materials kit, students construct an experimental apparatus and make sense of data collected with the IOLab and analyzed with Microsoft Excel. Rigorous labs include resistivity measurements using bare wires, the distance dependence of magnetic field strength from dipoles and quadrupoles, and the temperature dependence of power dissipated by an incandescent bulb. One or more of these labs will be presented in detail.

**PST1B05: 8:30-9:15 p.m. Simple Introductory Lab Activities on Measurements, Uncertainties and Graphing**

Poster – Gilbert F. Kuipers, Valley City State University, 101 College St. SW, Valley City, ND 58072; gilbert.kuipers@vcsu.edu

These were inspired to demonstrate the science behind post-harvest fruit and vegetable process equipment. Today's machines automatically grade and sort materials using weight, size, shape, color, density, and other physical characteristics. The necessary materials are easy to obtain and inexpensive. Although fresh items dry out;

dried beans, pasta, polished decorative rock pebbles, etc. can be reused. By measuring the dimensions and masses of individual potatoes and of individual unshelled peanuts the students produced models to reject foreign objects based on the concept of density as done with gravity tables or can be done with weight and photography. The concept of variation was introduced by recording the mass of a weighing dish as each item was added. The slope of the graph gave the average mass per item and the change in mass as each item was added gave the individual masses for further statistical analysis.

**PST1B06: 9:15-10:00 p.m. Teaching Physics Lab to Online Students**

Poster – John Matthew Long, Deakin University, School of Engineering, locked bag 20000, 75 Pigdons Road, Geelong, VIC 3220 Australia; john.long@deakin.edu.au  
Kenneth L. Chenery, Deakin University

One of the biggest challenges in teaching physics online is delivering lab instruction and practical skills to off-campus students. Since 1996, Deakin University in Australia has delivered an introductory physics course simultaneously to both distance/online and on-campus cohorts in engineering. Many of the off-campus students live in remote areas. The course has a significant lab component, worth 30 percent of the total assessment, and currently containing five experiments. We present a number of methods that we have employed to deliver lab experiences to off-campus students. These include weekend on-campus lab classes, remote-controlled experiments, video-presented experiments, real-time experiments broadcasted through web-conferencing, at-home electronics kits, and at-home experiments where students assembled their own materials. What worked and what did not will be discussed, as well as further suggestions and ideas. Our experience shows that it is possible to produce the same learning outcomes in lab for both online and on-campus cohorts.

**PST1B07: 8:30-9:15 p.m. The Niels Bohr Institute \$100 Gamma Ray Spectrometer**

Poster – Ian G. Bearden, Niels Bohr Institute, Blegdamsvej 17, Copenhagen, 2100 Denmark; bearden@nbi.dk  
Axel Boisen, Niels Bohr Institute

We present a very inexpensive gamma ray detector based on LYSO scintillator coupled to a Silicon photomultiplier (SiPM). The detector is powered by 4 9V batteries connected via a voltage regulator. Such a power supply is both rather inexpensive and has very low noise compared to most low cost laboratory power supplies. We will discuss the design and construction of the detector as well as possible uses in laboratory courses from introductory to advanced level.

**PST1B08: 9:15-10:00 p.m. Transcending Your Discipline: A Transdisciplinary Laboratory Course Provides Context and Quantitative Literacy Skills that Contribute to STEM Retention**

Poster – Sarah Formica, University of North Georgia, 82 College Circle, Dahlonega, GA 30597; sarah.formica@ung.edu

This poster describes an introductory, one-semester, transdisciplinary lab course that integrates concepts across biology, chemistry, physics, and mathematics, and develops basic quantitative literacy and stimulates student interest in STEM more effectively than traditional introductory lab courses in biology, chemistry, and physics. Students in the transdisciplinary lab showed higher quantitative reasoning and literacy gains than students in traditionally-taught science labs, and those gains were statistically significantly different between transdisciplinary students and traditionally-taught biology students. Retention rates of students in the transdisciplinary lab were also compared to students in the control groups and show that student retention in a STEM discipline was higher for students who participated in the transdisciplinary lab. These results suggest that a transdisciplinary approach to STEM lab classes benefits students by improving their mathematical reasoning skills and compelling students to continue with their STEM education.

**PST1B09: 8:30-9:15 p.m. Use an iPhone Accelerometer App to Evaluate Various Sport Helmets**

Poster – Hsuan Lillian Labowsky, Ridgewood High School, Ridgewood NJ, 627 East Ridgewood Ave., Ridgewood, NJ 07450-3394; hlabowsky@ridgewood.k12.nj.us

Using an iPhone Accelerometer App, students evaluate the impact force of various sport helmets. The “impact force” is created by dropping a helmet from a fixed height onto the floor. As opposed to standard helmet testing that measures external force, the iPhone is fastened inside the helmet to simulate the effect on the brain. The app records the acceleration components as a function of time. The data is transferred to and graphed in an Excel spreadsheet. Graphs show the “free fall” and the “impact” regions, although an app with a data collection rate greater than the available 30Hz is desirable. After testing an unmodified helmet, the students then add foam and/or crumple zones in attempts to improve cushioning. Students exercise the scientific method in data collection/interpretation and draw meaningful conclusions. The experiment is particularly timely/meaningful in light of the concern over sports-related concussions.

**PST1B10: 9:15-10:00 p.m. Using a Rubric to Teach Design Skills in Junior Lab**

Poster – Karen A. Williams, East Central University, 1100 E. 14th St., PMB D-5, Ada, OK 74820; kwilliams@ecok.edu  
Caleb Shi

Students are required to choose and design their own short research project in Junior Physics Lab. Students submit a proposal that I accept or reject. If rejected I guide them to a more viable project. The project is presented as their final exam. It is graded using an Inquiry and Analysis Value Rubric designed by the Association of American Colleges and Universities. Items assessed are topic selection, background from sources, the design process, the analysis, the conclusions of the project, and the limitations and implications of the findings. I find it a good rubric to assess the design of a project.

**PST1B12: 9:15-10:00 p.m. A Series of Optics Laboratory Projects Using Student Cell Phones**

Poster – Steven C. Sahyun, University of Wisconsin - Whitewater, 800 W Main St., Whitewater, WI 53190-1319; sahyuns@uww.edu

Modern cell phones have a number of optical properties useful for investigation in a student laboratory setting. This poster describes a series of laboratory activities involving student's smart phones for an optics course designed for third- and fourth-year undergraduates. Students investigated the index of refraction of the glass screen, color and display properties of the screen and flash lamp, sensor and lens characteristics, and used their phones as microscopes and spectrometers. This series of laboratory activities was developed so that students would have several laboratory experiments over the course of the semester as a way to relate to course material and to better appreciate the many optical properties in an object they carry and use on a daily basis.

**PST1B13: 8:30-9:15 p.m. Lab Activity of Projectile Motion Using Tracker**

Poster – Sechan Yoon, Harvest Christian Academy, PO Box 8260, Tamuning, GU 96931; sechan2001@hotmail.com

The Tracker video analysis and modeling program provides excellent opportunities for students to investigate and learn about kinematics and dynamics. A lab activity for projectile motion and pendulum motion is developed for students to use the Tracker program to analyze the motion and find the initial velocity. Using a table with a simplified finite difference method, students can compare to the Tracker program data and understand how the Tracker program works better. A set of in-



ries is used to estimate the related physical quantities like time and range of the object without directly using kinematics equations and to investigate the differential equations and its solution.

**PST1B14: 9:15-10:00 p.m. Boosting Student Engagement in the Introductory Physics Lab through Competition**

Poster – John R. Walkup, Fresno State University, 2345 E. San Ramon Ave., M/S MH37, Fresno, CA 93740; [jwalkup@csufresno.edu](mailto:jwalkup@csufresno.edu)

Roger Key, Fresno State University

Students often complete lab activities, but then fail to demonstrate any tangible understanding of the physics concepts targeted in the lesson. The authors surmise that much of the problem centers on students' passive approach to performing lab activities, where all work is stopped once they deem their results "good enough." In response, the authors have recast the lab activities as competitions, where students use the existing traditional lab activities as mere practice runs for students to brainstorm the most effective approach toward besting their lab classmates' performance. Such lab activities involve far less dependence on instructions and much more reliance on discussion and planning. The authors have found elevated levels of student resourcefulness and engagement. Furthermore, student evaluations have generated almost uniformly positive attitudes toward the competitive approach, even though students admitted increased frustration and pressure. Time demands on the lab teaching assistant are also significantly reduced.

**PST1B15: 8:30-9:15 p.m. Custom-built Vibrating Sample Magnetometer for Materials Characterization\***

Poster – Bryan M. Augstein, Towson University, Department of Physics, Astronomy, and Geosciences, 8000 York Road, Towson, MD 21252; [baugst1@student.towson.edu](mailto:baugst1@student.towson.edu)

William Zimmerman, Towson University: Department of Physics, Astronomy, and Geosciences

Jeffrey Klupt, Towson University: Department of Physics, Astronomy, and Geosciences

Dr. Vera Smolyaninova, Towson University: Department of Physics, Astronomy, and Geosciences

A vibrating sample magnetometer (VSM) is an instrument used to measure magnetic properties through sinusoidal vibrations of a magnetized sample in a uniform magnetic field. As the sample oscillates, a voltage is induced in two stationary pick-up coils. This voltage is proportional to the magnetic moment of the sample, and can be measured to a high degree of accuracy using a lock-in amplifier. This design was first proposed by Simon Foner and has been successfully used throughout the years in physics laboratories. This approach was used to create a vibrating sample magnetometer for materials characterization. The design of the VSM suitable for characterization of ferrofluids will be discussed.

\*This work is supported in part by FCSM Undergraduate research grant, GSA grant, and DARPA AMEBA grant.

**PST1B16: 9:15-10:00 p.m. Delayed-Choice Interference Experiment for the Entangled-Photon Undergraduate Laboratory\***

Poster – Enrique J. Galvez, Colgate University, 13 Oak Drive, Hamilton, NY 13346; [egalvez@colgate.edu](mailto:egalvez@colgate.edu)

Jhonny Castrillon, Boris A. Rodriguez, Omar Calderon-Losada, Universidad de los Andes, Colombia

We have developed a new undergraduate laboratory experiment with time-energy entangled photons that exploits the concept of delayed choice in quantum interference. Photon pairs produced by parametric down-conversion are entangled in energy and momentum. One photon is sent through a Mach-Zehnder interferometer. It reaches a detector immediately after exiting the interferometer. The energy-entangled partner is sent through a long optical fiber to an energy filter followed by a detector. The delayed-choice of filter bandwidth determines whether one sees interference or not. The experiment involves adding only a few optical components to an existing correlated-photon undergraduate laboratory. The experiment makes the students confront fundamental concepts of quantum interference.

\*NSF grant PHY-1506321

**PST1B17: 8:30-9:15 p.m. Elevating Measurement, Error, and Statistics to Prominence in the Introductory Physics Lab**

Poster – John R. Walkup, Fresno State University, 2345 E. San Ramon Ave., M/S MH37 Fresno, CA 93740; [jwalkup@csufresno.edu](mailto:jwalkup@csufresno.edu)

Roger Key, Fresno State University

Although measurement theory is a part of most introductory physics labs, its treatment is often superficial and relegated to mostly significant figures and percent error calculations. The latter is especially problematic, as comparisons to known/accepted values is relatively rare in real-world lab activities. The authors have instead shifted focus away from calibration tasks (i.e., comparing results to known values), elevating the importance of measuring random error to dominance. The authors will address NIST and ISO standards on error analysis, updated measurement vocabulary, and how traditional lab manuals are often outdated, inconsistent, and wrong. The authors will showcase lab activities centered on teaching students to understand (1) the connection between resolution, sensitivity, and variability, (2) the distinction between uncertainty and standard deviation, and (3) how the standard deviation, standard error, and confidence intervals drive experiment. One such experiment uses a competition atmosphere in a manufacturing process, akin to Six Sigma, designed to meet real-world, industrial objectives.

**PST1B18: 9:15-10:00 p.m. Even More Physics Experiments Using Your Smartphone**

Poster – Arturo C. Marti, UdelaR, Montevideo, Uruguay, Igua 4225 Montevideo, Montevideo 11400 Uruguay; [marti@fisica.edu.uy](mailto:marti@fisica.edu.uy)

Martin Monteiro, ORT University

Cecilia Cabeza, Cecilia Stari, UdelaR, Montevideo, Uruguay

Smartphone usage has expanded dramatically worldwide in recent years. Indeed, it is everyday more frequent to use smartphones as clocks, cameras, agendas, music players or gps. More remarkable is the habit, especially among young people, of bringing their smartphones every time and everywhere. It is impressive that smartphones usually incorporate several sensors, including accelerometers, gyroscopes, and magnetometers. Although these sensors are not supplied with educational intentions in mind, they can be employed in a wide range of physical experiments, especially in high school or undergraduate laboratories. Moreover, experiments with smartphones can be easily performed in non-traditional places as playgrounds, gyms, travel facilities, among many others. We show some of the capabilities of the smartphones and discuss some interesting physics experiments using them. The selected experiments involve accelerometer, gyrometer, magnetometer, luxometer and proximity sensors. It is worth mentioning that this technology allows the simultaneous use of different accelerometers.

Additional information: <http://smarterphysics.blogspot.com>.

**PST1B20: 9:15-10:00 p.m. Explanation of Rotation Mechanism of Liquid Film Motor Via Ions**

Poster – Hongzhi Zhu, No.2 Dongnandaxue Road Jiangning District Nanjing, Jiangning 211102; [zhzzhz990323@126.com](mailto:zhzzhz990323@126.com)

We present a qualitative explanation of the rotation mechanism of the liquid film motor via movement of ions. Principle of electrolytic cell is introduced into our model, in which the essence of the crossing current in liquid is the directional movement of ions and as soon as an ion has reached the electrode, electrons are

exchanged so that the ion loses its charges. Several quantitative analytic results involving the speed of rotation and the threshold voltage of the crossing current are obtained. We find that the interaction of the electrolytic cell and the polarization equilibrium maintained by the external electric field causes stable one-way flows in two sides along the electric field in adverse directions. The flows of ions lead to the rotation of the whole film. Though traditional theories via polarization of molecules can both explain the holistic rotation, Our theory can perfectly explain the local flow in high concentration film which could hardly be explained by traditional theories, and most experimental phenomena observed in direct current electric fields are interpreted well.

**PST1B22: 9:15-10:00 p.m. Faradaymeter: Arduino-based Precision Instrument for High School Labs for Electromagnetism**

Poster – Sidharta MJ Vadaparty, Montgomery High School, 85 Millers Grove Road, Belle Mead, NJ 08502-4300; shvadaparty@yahoo.com

Electromagnetism is central to advanced physics and should be internalized by high school students through hands-on experiments. However, concepts like Faraday's law are first demonstrated through qualitative experiments but quickly transitioned to memorization of formulas. Additionally, commercially available instruments which can fill this learning gap are often prohibitively expensive. In this presentation, we introduce an instrument, the Faradaymeter, which measures the induced voltage in a coil by a changing magnetic field. The Arduino-based electronics allow students to collect data without the necessity of an oscilloscope, making it affordable, customizable and open-sourced. This platform encourages students to design their own creative experiments and quantitatively rediscover the laws of electromagnetism: Faraday's Law, Biot-Savart's Law, and Lorenz's Law. Students can do this by adjusting the following variables: angular speed of a rotating magnet, the distance between the coil and the magnet, the diameter of the coil, and length of the wire used.

**PST1B23: 8:30-9:15 p.m. Fitting Parameter Uncertainties**

Poster – Robert Deserio, University of Florida, Department of Physics, Gainesville, FL 32611-8440; deserio@phys.ufl.edu

Simple expressions are presented for the uncertainties in model parameters obtained from fitting programs. They require the uncertainties of the input data and the construction of the Jacobian matrix as the derivative of each fitted value with respect to each fitting parameter. The formulas are demonstrated for data from our muon lifetime experiment where Poisson-distributed input data is governed by an exponential decay. The Microsoft Excel Solver program is used to perform properly weighted fits using either of two equivalent techniques: one based on the maximum likelihood principle and the other based on the iterated least squares method. Excel's built-in array formulas are then used to obtain the parameter covariance matrix, from which the uncertainties are determined. Parameter uncertainties based on the  $\Delta x^2 = 1$  rule are also determined and shown to be in agreement.

**PST1B24: 9:15-10:00 p.m. Interference of Control of Variable Skills with Causal Reasoning**

Poster – Lindsay Owens, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623; lmosch@rit.edu

Kathleen Koenig, University of Cincinnati

Lei Bao, Ohio State University

Understanding how to create a controlled experiment, as well as using causal reasoning to synthesize experimental results are critical skills in the laboratory setting. Students' abilities to interpret what caused an experimental outcome were evaluated in think-aloud style interviews. Interviews were conducted with a variety of algebra-based and calculus-based students in introductory physics lab courses. The majority of interview participants showed difficulty in answering this causal reasoning task and treated the task as if it were instead testing their control of variables (COV) knowledge. The use of a second causal reasoning task confirmed that students' COV-reasoning skills were interfering with their causal reasoning abilities. Results from these interviews were used to provide meaning to quantitative data obtained from a post reasoning test administered to all students in the introductory lab courses. The quantitative data echoed the answer selections of the interview participants for both causal reasoning tasks.

**PST1B25: 8:30-9:15 p.m. Things to Consider When Updating Introductory Physics Labs**

Poster – Darwin R. Church, University of Cincinnati Clermont College, 4200 Clermont College Drive, Batavia, OH 45103; darwin.church@uc.edu

There are multiple reasons why introductory physics labs need to be updated, and there are different approaches to consider in the process. A good place to start, if you are considering revising physics labs, is the American Association of Physics Teachers Recommendations for the Undergraduate Laboratory Curriculum. It is an excellent resource and includes student learning outcomes on which to focus. The challenge is to implement them with the limitations often faced with laboratory instruction. Having recently updated two semesters of introductory physics labs, this presentation will examine some of the reasons to update labs and common approaches that are popular today. The advantages and disadvantages of each will be highlighted.

## Physics Education Research

**PST1C01: 8:30-9:15 p.m. Motivational Characteristics of Underrepresented Ethnic and Racial Minority Students in Introductory Physics Courses**

Poster – Zeynep Y. Kalender, Department of Physics and Astronomy, University of Pittsburgh 2000 Wendover Street Apt 3, Pittsburgh, PA 15217; zyk2@pitt.edu

Emily Marshman, Department of Physics and Astronomy, University of Pittsburgh

Timothy Nokes-Malach, Learning Research and Development Center, University of Pittsburgh

Christian Schunn, Learning Research and Development Center, University of Pittsburgh

Chandralekha Singh, Department of Physics and Astronomy, University of Pittsburgh

Many hypotheses have been put forth to explain the under-representation and under-performance of historically marginalized racial and ethnic minority students in physics. While much research has focused on the relations between prior knowledge and performance, less work has examined the potential interactive role of student motivation. In particular, expectancy value theory posits that students' beliefs about their expectations for success (e.g., self-efficacy) and the value they associate with an academic task (e.g., intrinsic interest) influence their persistence and performance. In this study, we conducted a longitudinal analysis of students' motivational characteristics in introductory physics courses by administering surveys at three points during the year. White, Asian, and underrepresented racial/ethnic minority students' self-efficacy and interest in physics are reported, and implications for instruction are discussed. We thank NSF for the support.

**PST1C02: 9:15-10:00 p.m. Network Analysis of Language Used in Quantum Mechanics.**

Poster – Christopher A. Oakley, Spelman College, 350 Spelman Way, Atlanta, GA 30314; coakley@spelman.edu

Students and faculty at a large research university were interviewed about their expectations of an undergraduate quantum mechanics course. Interview questions focused on preparatory content and content to be covered in the course. Network analysis methodologies have been applied to the interview responses to identify words commonly used together for faculty and student responses. From the quantitative data, we look for common themes in expected preparation and course content.

**PST1C03: 8:30-9:15 p.m. PIE-C: Physicists Interviewing Engineers about Computation**

Poster Thomas Finzell, University of Michigan, 8795 Spinnaker Way, Apt. C1, Ypsilanti, MI 48197; chimera31@gmail.com

Sameer Barretto, University of Michigan

Computational problem solving has become a fundamental pillar across all STEM fields; it is now virtually impossible to work in research and/or design without using some form of computation. Despite the ubiquity of computation, there is a great deal of variance in how computers are used to solve problems in the different STEM fields. As part of a broader campaign to integrate computation into a large “physics for engineers” lecture course, we interviewed faculty from both physics and (several) engineering departments, to get a better understanding of their views on computation, both professionally and in the classroom. We present results from these interviews, which shed light on the differences in computational philosophies among professionals in different STEM fields. This data can be used to help inform how computation in “physics for engineers” courses can be better aligned with engineering practices.

**PST1C04: 9:15-10:00 p.m. Researching Experiences in a Cohort Program to Influence Transfer Self-Efficacy**

Poster – Laura A. Wood, Michigan State University, 220 Trowbridge Rd., East Lansing, MI 48824; woodlau5@msu.edu

Angela J. Little, Vashti Sawtelle, Michigan State University

There remains a great deal of research to do on improving the transfer experience for students transitioning from two-year colleges to four-year colleges. In this presentation we will describe data collected from interviewing current students at Michigan State University who are members of a cohort program that will be adapted for transfer students to join starting fall 2018. This cohort program is designed to give first-year students – intending to major in the natural sciences, and from traditionally underrepresented backgrounds – support in academics, research experiences, and the social experience of integrating into the university. The interview protocol elicited discussion of these students’ self-efficacy to complete their science degrees, navigate the academic requirements, and continue in their chosen life paths, specifically drawing out mastery, vicarious learning, and social persuasion experiences. We will discuss how key elements of student experiences in the cohort program may support developing self-efficacy in the transfer process.

**PST1C05: 8:30-9:15 p.m. Retention of Knowledge Gained in Introductory Physics**

Poster – Michael P. Orleski, Misericordia University, 301 Lake St., Dallas, PA 18612; morleski@gmail.com

Standardized concept inventories given as pre-tests and post-tests are a common way to measure knowledge gains by students in courses. Students participating in this study were given the Force Concept Inventory (FCI) a third time approximately one semester after their first-semester introductory physics course ended in an attempt to gauge longer-term retention of content knowledge. The normalized gain scores calculated using pre-test and post-test scores are compared to normalized gain scores calculated using the pre-test and the third attempt. At Misericordia University there are two distinct populations who take algebra-based introductory physics. Occupational Therapy students used for this study experienced an integrated, investigative curriculum called LEAP while Pre-Doctor of Physical Therapy students used a traditional curriculum with lecture and a separate lab. The study attempts to determine if there is a difference in retention between these two different teaching styles.

**PST1C06: 9:15-10:00 p.m. Social Positioning and Consensus Building in “Board” Meetings With Disagreements**

Poster – Brant E. Hinrichs, Drury University, 729 N. Drury Lane, Springfield, MO 65802; bhinrichs@drury.edu

David T. Brookes, California State University, Chico

Jake Nass, Drury University

This poster describes a whole-class whiteboard meeting and analyzes several examples from a college calculus-based introductory physics course and junior-level E&M course taught using modeling instruction. Classes were divided into 3-6 groups of 2-4 students each. Each group created a solution to the same problem on a 2'x 3' whiteboard. The groups then formed a large circle in the center of the classroom with their whiteboards resting against their knees facing in to the rest of the group. The instructor was outside the circle and interjected rarely. Examples are given of conversations where students did and did not overcome sharp disagreements to eventually reach whole-class consensus. We examine how social positioning contributed to students either successfully examining and resolving different ideas or failing to do so. We test the hypothesis that students who “hedged” their statements seemed to “open up” the space for discussion, while those who were more direct seemed to “close” it down.

**PST1C08: 9:15-10:00 p.m. Student Attitudes in Introductory Physics: How Students Experience Physics Courses**

Poster – Whitney Faries, \* George Mason University, 625 McCauliff Drive, Richmond, VA 23236; whitneylfaries@gmail.com

Robin Gordon, Benjamin W. Dreyfus, George Mason University

Quantitative instruments such as the Colorado Learning Attitudes about Science Survey (CLASS) are one tool to assess student views about physics, but the interaction between course environments and student responses can be complex. We look at two different sets of classes – algebra-based and calculus-based introductory physics – and examine the changes in student attitudes about physics, commitment to physics, and interest in the subject over the two-semester sequence. The survey data (obtained at different points during the year) are supplemented by focus groups and individual interviews with students to examine the elements of the instructional environment that have impacts on students’ attitudes.

\*Sponsored by Benjamin W. Dreyfus

**PST1C09: 8:30-9:15 p.m. Student Attitudes in Introductory Physics: Quantitative Trends Across Courses**

Poster – Robin Gordon, \* George Mason University, 2031 N Woodrow St, 1, Arlington, VA 22207; rgordon7@masonlive.gmu.edu

Whitney Faries, Benjamin W. Dreyfus, George Mason University

Student attitudes and beliefs toward physics can be influenced by a variety of factors. How a student feels towards physics can contribute to their success and understanding of the course. We present quantitative data from the first and second semester of both algebra-based and calculus-based physics courses. Students in these classes took the Colorado Learning Attitudes about Science Survey (CLASS) at the beginning and end of the course. We analyze relationships between CLASS results and (1) course grades, (2) concept inventory scores, (3) course type and (4) student major, and contextualize these results within larger datasets from LASSO (Learn-

ing About STEM Student Outcomes). This analysis sheds light on the ways that different populations of physics students may experience a different impact from the course.

\*Sponsored by: Benjamin Dreyfus

### **PST1C10: 9:15-10:00 p.m. Student Attitudes on Group Exams in STEM Courses**

Poster – Steven F. Wolf, East Carolina University Department of Physics, 1000 E 10th St., Greenville, NC 27858-4353; wolfs15@ecu.edu

Erik Carr, Timothy Sault, East Carolina University Department of Physics

Administering group examinations is a teaching technique that has been gaining traction in recent years, and many faculty implement and assess group exams in different ways. It is not well-understood how students react to each of these faculty choices. Moreover, we want to uncover how students believe group exams affect them, aside from receiving a better grade. To accomplish this we have developed a semi-structured interview protocol, and are interviewing students who have taken group exams with different STEM faculty. We will present preliminary findings from these interviews.

### **PST1C11: 8:30-9:15 p.m. Student Objections to and Understanding of Non-Cartesian Unit Vector Notation in Upper-Level E&M**

Poster – Brant E. Hinrichs, Drury University, 729 N. Drury Lane, Springfield, MO 65802; bhinrichs@drury.edu

The upper-level E&M course involves extensive integration of vector calculus concepts and notation with abstract physics concepts like field and potential. Students take what they learned in math and apply it to help represent and make sense of the physics. Previous work showed that physics majors at different levels (pre- and post- E&M course, 1st year graduate students) had great difficulty using non-Cartesian unit vector symbols appropriately in a particular context. Since then we have developed a series of problems students work on in groups and discuss as a whole class to help them confront and resolve some of their difficulties. This poster presents those problems, typical in-class group responses, and three years of post-test data. Results show that students have (i) a very strong initial negative reaction to the vagueness of the  $\hat{r}$  symbol, and (ii) an improved functional understanding of the notation as demonstrated by a better ability to use the symbols correctly.

### **PST1C12: 9:15-10:00 p.m. Student Outcomes Across Collaborative-Learning Environments**

Poster – Xochitl M. Herrera, CSU Chico, 1080 Columbus Ave. Apt 2, Chico, CA 95929; xherrera@mail.csuchico.edu

Jayson Nissen, Benjamin V. Dusen, CSU Chico

The Learning Assistant (LA) model supports instructors in implementing research-based teaching practices in their own courses. In the LA model undergraduate students are hired to help facilitate collaborative learning activities. Most of these activities have research supporting their efficacy. We investigated if the use of LAs is associated with improved student outcomes beyond the improvement caused by the introduction of these collaborative-learning activities. Using the Learning About STEM Student Outcomes (LASSO) database, we examined student learning from 112 first-semester physics courses that used either lecture-based, collaborative learning without LAs, or LA-supported instruction. We measured student learning using responses from 5,959 students on the Force and Motion Conceptual Evaluation (FMCE) or Force Concept Inventory (FCI). Results from Hierarchical Linear Models (HLM) indicated that LA-supported courses had higher posttest scores than collaborative courses without LAs and that LA-supported courses that used LAs in laboratory and recitation had higher posttest scores than those that used LAs in lecture.

### **PST1C13: 8:30-9:15 p.m. Student Questions in Science, “Scientific” Methods, and Self-Determination Theory**

Poster – Jim M. Tisel, Holy Family Catholic High School, 8101 Kochia Lane, Victoria, MN 55386; tise0002@umn.edu

What questions do fifth-grade students pose when they undertake relatively unstructured investigations? What patterns exist in these questions? The presenter did a within-case and cross-case analysis of 351 written and oral questions that were generated by 24 students during one 40-minute period of student investigation of pendulum motion. A framework of analysis that used the Self-Determination (Deci and Ryan, 1981) categories of autonomy, competence, and relatedness proved to be effective in understanding the motivation behind the questions and the role they played in the investigations. Key similarities and differences between the approaches used by students and the Lawson (2003) hypothetico-predictive model of science were identified. The results of this study will help educators to effectively plan inquiry instruction for students.

### **PST1C14: 9:15-10:00 p.m. Students' Attention Patterns in Solving Synthesis Physics Problems\***

Poster – Bashirah Ibrahim, The Ohio State University, School of Teaching and Learning, 231 Arps Hall, 1945 N. High St., Columbus, OH 43210; bashirah2001@gmail.com

Lin Ding, The Ohio State University

Synthesis problems are tasks comprising two or more distinct concepts that are typically from different chapters and are separated in the teaching timeline. We use eye tracker to explore freshmen physics students' attention patterns when they solve sequential and simultaneous synthesis tasks. Sequential problems require successive applications of multiple concepts, while simultaneous problems involve concurrent applications of different concepts. We found that regardless of the type of synthesis problems, the students spent more time reading the text (50%-90% of fixation time) than reading diagrams. Between the two synthesis types, the students allocated more attention to the diagrams in sequential problems (29%--79% of the fixation time) than to those of simultaneous problems (1%--19%). Further, the students tended to focus more on aspects of the diagrams requiring interpretation and derivation of information for the sequential tasks as opposed to the simultaneous ones.

\*This work is partially sponsored by NSF and OSU EHE/ACH Seed Grant.

### **PST1C15: 8:30-9:15 p.m. Students' Reasoning Paths Through the Lens of Dual Process Theories\***

Poster – Brianna Santangelo, North Dakota State University, 1340 Administration Ave., Fargo, ND 58102; brianna.santangelo@ndsu.edu

Mila Kryjevskaja

When faced with unfamiliar situations, students are more likely to rely on intuitive reasoning rather than formal knowledge and skills developed during instruction. In order to pinpoint specific factors and instructional circumstances that lead to productive and unproductive reasoning strategies, we have been developing sequences of questions that allow for the disentanglement of student conceptual understanding, reasoning, and intuition. We used these sequences in introductory algebra-based and calculus-based Mechanics courses at a large research university. The Dual Process Theories (DPT) of reasoning are used to interpret students' responses. Written answers, explanations, and self-reflections (viewed through the lens of DPT) reveal student approaches to reasoning: reliance on intuition, development of heuristics, use of confirmation bias, and other reasoning decisions that lead to the final answer.

\*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432052, DUE-1432765.

### **PST1C16: 9:15-10:00 p.m. Students' Use of Mathematics While Working on Physics Assessments**

Poster – Amali Priyanka Jambuge, Kansas State University, 1600 Hillcrest Dr., Apt. V25, Manhattan, KS 66502; amali@phys.ksu.edu

James T. Laverty, Kansas State University

Exams and homework are the most common ways of assessing students' knowledge. These assessments often focus only on assessing physics concepts. With the introduction of the Next Generation Science Standards (NGSS), there is growing interest in assessing not just what students know, but what students can do with their knowledge. The Three-Dimensional Learning Assessment Protocol (3D-LAP) is a tool developed to help people design college assessment tasks that align with NGSS. The purpose of this study is to investigate how well such tasks can assess students' abilities with the scientific practice "using mathematics." We developed an exam with questions based on the 3D-LAP and the exams were given to students in an interview setting using a think-aloud protocol. This poster will focus on some interesting aspects of students' responses to the questions. This work will inform the development of future college level physics assessments.

### **PST1C17: 8:30-9:15 p.m. Supporting Teaching Autonomy in the New Faculty Workshop**

Poster – Stephanie V. Chasteen, Chasteen Educational Consulting, 247 Regal St., Louisville, CO 80027; stephanie.chasteen@colorado.edu

Rajendra Chattergoon, University of Colorado Boulder

Over the past 10 years, the use of active learning in physics classrooms has become more mainstream. We have noticed a possible effect of this change in our disciplinary culture through the evaluation of the New Physics and Astronomy Faculty Workshop (NFW)<sup>1</sup>, in that many faculty come to the workshop already highly interested and motivated in using active learning. We have also observed complaints from some faculty participants who feel overly "persuaded" of the utility of active learning during the course of the workshop. We interpret these results within a framework of participant autonomy: To feel intrinsically motivated, participants must feel in control of their own teaching decisions and persuasion can be seen as not autonomy-supporting. We will highlight results from the past 3 years of NFW evaluation, including participant characteristics, outcomes, and feedback, and how changes in the NFW program have better supported participant autonomy.

1 - <http://www.aapt.org/Conferences/newfaculty/nfw.cfm>, sponsored by AAPT, APS and AAS. We acknowledge funding from NSF-1431638.

### **PST1C18: 9:15-10:00 p.m. Supporting Undergraduate Physics Students who are the Guardians of a Minor**

Poster – Rose Young, St Marys College of Maryland, 45551 Knockeyon Lane, Great Mills, MD 20634-2486; Rnyoung@smcm.edu

Parents or guardians who are pursuing an undergraduate degree in physics have many barrier to their success. In this poster, I explore the possibility of extending the standard notions of student support systems to include classroom practices which have enabled undergraduate students to succeed and thrive while pursuing their degree. I ask: Can physics departments be supportive of students with dependent children, and if so, how? By studying students who have/ are thriving in physics, engineering, math and computer science undergraduate degree programs around the United States, the author examines strategies that administrators and faculty use to make their departments supportive and inclusive for student parents. The poster describes the non-traditional challenges physics undergraduates who are the guardians of minors can face, as well as the support systems that may be created, and policies and practices that ensure their success.

### **PST1C19: 8:30-9:15 p.m. Surviving STEM: Pathways to Getting a STEM Degree**

Poster – Steven F. Wolf, East Carolina University Department of Physics 1000 E 10th St., Greenville, NC 27858-4353; wolfs15@ecu.edu

Ryan Mezera, East Carolina University Department of Physics

Sarit Johnson, Kevin White, East Carolina University Department of Social Work

There have been multiple national calls to create more STEM majors (e.g., PCAST 2014). In order to achieve this goal, STEM faculty need to understand what draws students to our discipline, and what can push them away from it. There are many factors that contribute to successfully obtaining a four-year college degree. A survival analysis will model the time to an event, in this case either dropping out or graduation. Kaplan Meier, Nelson Aalen, and Cox proportional hazard models will be used to develop survival, lifetime distribution, and hazard functions to see how different factors contribute to students progress in pursuit of STEM degrees at ECU over a four year period. Determining factors that have a high-event density will help to identify groups most at risk in order to promote retention.

### **PST1C20: 9:15-10:00 p.m. Teaching about Racial Equity in Physics Classrooms**

Poster – Elizabeth A. Schoene, South Seattle College, 6000 16th Ave. SW, Seattle, WA 98106; elizabeth.schoene@seattlecolleges.edu

Abigail R. Daane, South Seattle College

Sierra R. Decker, Seattle Pacific University

Vashti Sawtelle, Michigan State University

It may seem daunting to broach the subject of racial inequity in a physics classroom. After all, the idea of a (often White) instructor in power tackling a sensitive topic such as social justice can be scary in any classroom. That physics is typically viewed as a "culture with no culture" compounds the issue. However, ignoring the striking underrepresentation of ethnic/racial minorities and women in the physics classroom and the field at large is a great disservice to all our students. We take the position that the persistence of representation disparities in physics is evidence that culture plays a role in who and what is involved. Instructors have an opportunity to explicitly address the absence of equitable circumstances and highlight the obstacles that contribute to the disparity. We describe a pathway for integrating an equity unit into a college physics classroom and share some students' reflections about their experiences.

### **PST1C21: 8:30-9:15 p.m. The Effect of Giving Explicit Incentives to Correct Mistakes on Subsequent Problem Solving in Quantum Mechanics\***

Poster – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Ben Brown, University of Pittsburgh

One attribute of experts is that they learn readily from their own mistakes. Physics experts are unlikely to make the same mistakes when asked to solve a problem a second time, especially if they have had access to a correct solution. Here, we discuss a study spanning several years in which advanced undergraduate physics students in a quantum mechanics course were given the same four problems in both the midterm exam and final exam. Approximately half of the students were given incentives to correct their mistakes in the midterm exam and they could get back up to 50% of the points lost on each midterm exam problem. The solutions to the midterm exam problems were provided to all students but those who corrected their mistakes were provided the solution after they submitted their corrections to the instructor. The performance on the final exam on the same problems suggests that students who were given incentives to correct their mistakes significantly outperformed those who were not given an incentive. The incentive to correct the mistakes on the midterm exam had the greatest impact on the final exam performance of students who performed poorly on the midterm exam.

\*We thank the National Science Foundation for support.

**PST1C23: 8:30-9:15 p.m. The Nature of Teacher Talk in Faculty Online Learning Communities**

Poster – Alexandra C. Lau, University of Colorado Boulder, and JILA, Department of Physics, 390 UCB, Boulder, CO 80309; [alau693@gmail.com](mailto:alau693@gmail.com)

Melissa H. Dancy, University of Colorado Boulder

Charles Henderson, Western Michigan University

Andy Rundquist, Hamline University

The New Faculty Workshop Faculty Online Learning Community (NFW-FOLC) supports approximately 10 NFW participants in the year following their participation in the workshop. Members of the NFW-FOLC meet biweekly via a video conferencing platform to hear from experienced practitioners of various teaching techniques as well as to discuss their teaching with their peers. During some meetings, participants have an extended period of time to share a “State of the Classroom” update with their cohort and gather feedback on challenges they are encountering. One of the main goals of the NFW-FOLCs is to promote sustained and high-quality implementation of Research Based Instructional Strategies. It is thus important for us to know how FOLC cohort members are talking about their teaching and responding to each other’s talk. In this poster we report on our analysis of the quality and characteristics of “State of the Classroom” updates from a selection of NFW-FOLC members.

**PST1C24: 9:15-10:00 p.m. Transforming Modeling Instruction in a Large Classroom Environment**

Poster – Idaykis Rodriguez, Florida International University, 11200 SW 8th St. v176, Miami, FL 33199; [irodr020@fiu.edu](mailto:irodr020@fiu.edu)

Geoff Potvin, Laird H. Kramer, Florida International University

In the past four years, FIU has expanding its offering of modeling instruction (MI) for introductory physics from a 30-student classroom to one that accommodates up to 100 students using multiple teaching resources and implementing several structural changes. MI is a studio-based, active learning curriculum that is derived from social constructivist theories of learning. This expanded classroom has been found to consistently support student learning with strong conceptual learning gains across at least four different instructors. In this talk, we discuss the development of the larger classroom offering, including the strategic use of LAs, the coordination of multiple discussion circles, preparatory meetings with an instructional team spanning multiple sections, and detailed curricular modifications that supported the expansion of MI.

**PST1C25: 8:30-9:15 p.m. Transforming to Three-Dimensional Learning Across Institutions**

Poster – Lydia G. Bender, Kansas State University, 1228 N 17th St., Manhattan, KS 66506; [lbender@ksu.edu](mailto:lbender@ksu.edu)

James T. Laverty, Kansas State University

There have been many attempts to transform physics courses in sustainable ways, but little research on how to effectively make change. Three-dimensional learning (3DL) is currently being implemented in several college classrooms with varying levels of success. This suggests that the different environments and cultures have an effect on the implementation and sustainability of 3DL. We are working to understand the barriers that hinder the transformation to 3DL-courses. This research is centered on members of a faculty learning community that investigates and discusses implementing 3DL in their classrooms. The purpose of this work is to determine what factors encourage and discourage faculty from adopting 3DL frameworks, and how adopting this framework changes student outcomes across institutions. Identifying these factors will help us understand how cultures and classrooms can be efficiently transformed to 3DL.

**PST1C26: 9:15-10:00 p.m. Triads, Transitivity, and Group Formation in Student Networks**

Poster – Timothy Malcolm Sault, East Carolina University, 2706 Stantonburg Rd. Apt. 1B Greenville, NC 27834-7269; [Timsault@gmail.com](mailto:Timsault@gmail.com)

Hunter G. Close, Texas State University

Steven F. Wolf, East Carolina University

Actor level social network measures give information that is useful for analyzing the members of a network as well as attributes of their interactions. However, to understand the development of the network as a whole as well as the formation of group collaboration, a different kind of measure is required. Ironically, to understand the macroscopic interactions of a network, one only needs to examine three people at a time. When a single person forms a strong bond with two people, it is likely that these two people will also form a bond with each other. This ‘friend of my friend is my friend’ concept is called transitivity, and it is intimately linked to group formation. Triads can also show us the formation of status levels within a network through structural hierarchy. We will examine the development of structural hierarchy and transitivity over the course of a semester in the context of group physics exam student networks.

**PST1C27: 8:30-9:15 p.m. Truly Representative Samples for Conceptual Evaluation Instrument (CFI) Development**

Poster – Rebecca Lindell, Tiliadal STEM Education Solutions, 5 N 10th St Suite A-1, Lafayette, IN 47901; [rlindell@tiliadal.com](mailto:rlindell@tiliadal.com)

Dawn Meredith, University of New Hampshire

James Vasenka, University of New England

Daniel Young, University of North Carolina

While developing the methodology to create the Fluid Motions Conceptual Evaluation Instrument (FMCIE) for use with the introductory physics for life science (IPLS) courses, we realized that to produce a reliable, valid, and fair conceptual evaluation instrument, we needed a truly representative sample of students from IPLS courses throughout the country at both private and state schools. We needed a sample that represented the variety of different students taking such a course, as well as where they took the course. In this poster, we will outline the methods utilized to create this representative sample to ensure representation of the different populations who take IPLS across the country.

**PST1C28: 9:15-10:00 p.m. Undergraduate Students’ Conceptual Understanding of Eclipses**

Poster – Craig C. Wiegert, University of Georgia, Dept. of Physics and Astronomy, Athens, GA 30602-2451; [wiegert@physast.uga.edu](mailto:wiegert@physast.uga.edu)

Matthew Parker, University of Georgia

Research literature on conceptual understanding of the mechanisms of solar and lunar eclipses, and more generally lunar phases, has tended to focus on middle-school and high-school student populations. Taking advantage of the excitement surrounding the Great American Solar Eclipse of 2017, we surveyed undergraduate STEM and non-STEM majors on their conceptual understanding of eclipses. We report on the results of this survey and its implications for undergraduate general science education.

**PST1C29: 8:30-9:15 p.m. Undergraduates Learning of Basic Physics Curriculums and Influence Factors Correlation**

Poster – Shihong Ma, Fudan University, 220 Handan Road, Shanghai, SHANGHAI 200433 CHINA shma@fudan.edu.cn

Chenlu Shen, Fudan University

This paper tracks the performance of freshmen in the process of undergraduate basic physics course, including a pretest of physical concepts at the beginning of the first semester and periodical tests to continuously examine students' level of curriculum knowledge and teaching gains. The test results reflect gender differences and regional characteristics. We analyze the correlation of influence factors on learning of content knowledge. Detailed research on regional characteristics of students is conducted through comparing senior high school textbooks and syllabus from different areas, especially focus on the analysis of course content differences among Shanghai, Zhejiang and Shandong, as well as the corresponding test results and gains of undergraduate students from the three provinces. The result comes out that freshmen's periodical test score is positively related to their background of content knowledge to some extent, however, it shows no significant relevance with subsequent physics learning gains.

**PST1C30: 9:15-10:00 p.m. Understanding Model Revision as Changes in Mechanistic Reasoning about Systems\***

Poster – Michael C. Wittmann, University of Maine, 5709 Bennett Hall, University of Maine, Orono, ME 04469-5709; mwittmann@maine.edu

Lauren Barth-Cohen, University of Utah

Recent science teaching standards have highlighted the role of model revision as a scientific practice and there is common agreement that models should incorporate scientific mechanisms. Yet, there is little agreement in the literature about what model revision entails and how to scaffold students' model revision. Model revision happens at different time scales, different grain sizes, and in many different ways. We propose the use of a framework that looks at the role of mechanistic reasoning in the models being revised. We present four episodes from a ninth grade classroom activity using Energy Theater to model the roughly steady state temperature of the Earth. We look at the entities, actions, and other elements of the model, and show that the ways in which they change are consistent with Russ's framework of mechanistic reasoning.

\*Sponsored in part by NSF grants 0962805 and 1222580.

**PST1C31: 8:30-9:15 p.m. Unique Assessments in the BLISS Physics Course for Life Sciences**

Poster – Vashti A. Sawtelle, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824-2320; davisvas@gmail.com

Kathleen Hinko, Michigan State University

Creating a physics course by blending elements of research-based transformations requires a strategic approach to assessment. At Michigan State University we have developed an introductory physics sequence for life science students with goals of connecting the disciplines of physics, biology, and chemistry and building positive relationships with physics. To achieve these goals, we employ a Modeling Instruction physics curriculum in a studio-style classroom format, and we incorporate both computational simulations and experimental data analysis of complex biological phenomena. The unique learning environment created by the blending of these curricular, structural, social, and physical elements necessitates that we consider our assessment of students very carefully. In this poster we present on our overall approach to assessment in this course and how it aligns with our learning goals and course activities. We also describe several modifications to typical assessments in transformed classrooms, including video lab reports and Twitter whiteboard meetings.

**PST1C33: 8:30-9:15 p.m. Using Grounded Cognition to Improve Physics Diagrams**

Poster – Amber Sammons, Illinois State University, 2006 Kaskaskia Drive, Springfield, IL 62702; arsamm1@ilstu.edu

Jacob Cermak, Raymond Zich, Rebecca Rosenblatt, Illinois State University

Diagrams are ubiquitous in STEM. These diagrams vary from problem solving tools (like force diagrams) to ways to visualize concepts (like fields) or understand the math (like graphs). While a fair amount of research has been done on student difficulties with these diagrams, only a small amount of research has been done on ways to improve these diagrams. In this study, we used grounded cognition theory to explore modifications to physics diagrams so that students naturally perceive the correct physical concepts when viewing the diagrams. Specifically, we investigated how color variations to motion maps affected student ability to rank velocity and acceleration at different times and what illustrations of pipe fluid dynamics can best improve student understanding of the Venturi effect, i.e. the pressure and speed relationship. Findings indicate that these modified images are not easier as pre-test items but yield better student learning when paired with feedback.

**PST1C34: 9:15-10:00 p.m. Using Machine Learning to Predict Integrating Computation into Physics Courses**

Poster – Nicholas Young, Michigan State University, 567 Wilson Road, East Lansing, MI 48824; youngn18@msu.edu

Marcos D. Caballero, Michigan State University

Computation is a central aspect of 21st century physics practice; it is used to model complicated systems, to simulate impossible experiments, and to analyze mountains of data. Physics departments and their faculty are increasingly recognizing the importance of teaching computation to their students. We recently completed a national survey of faculty in physics departments to understand the state of computational instruction and the factors that underlie that instruction. The data collected from the 1257 faculty responding to the survey included a variety of scales, binary questions, and numerical responses. We then used supervised learning to explore the factors that are most predictive of whether a faculty member decides to include computation in their physics courses. We find that personal, attitudinal, and departmental factors vary in usefulness for predicting whether faculty include computation in their courses. We will present the least and most predictive personal, attitudinal, and departmental factors.

**PST1C35: 8:30-9:15 p.m. Variations in Conversational Routines Across Two Faculty Communities**

Poster – Adriana M. Corrales,\* San Diego State University, CRMSE, 6475 Alvarado Road, Ste 206, San Diego, CA 92120; acorrales2@sdsu.edu

Chandra Turpen, University of Maryland

Fred Goldberg, San Diego State University

Meghan Clemons, Tennessee Technological University

Edward Price, California State University San Marcos

Across educator professional development efforts, there is significant momentum around building professional learning communities. More research however is needed on how the design and emergent norms of such communities enable or constrain particular learning opportunities for educators. In this presentation, we share a comparative analysis of the conversations unfolding in two distinct faculty communities (associated with the Next Generation Physical Science and Everyday Thinking Faculty Online Learning Community project [1]). We choose to focus on moments in their online conversations when seemingly similar issues or topics arise (e.g. concerns about pacing). By comparing these moments, we demonstrate important differences in how the instructional problem is posed and in the conver-

sational routines across these two groups. We illustrate how these differences open up and close off opportunities to learn [2].

\*Sponsored by Fred Goldberg [1] Work supported by NSF Grant 1626496 [2] I. S. Horn & B. D. Kane (2015). *Journal of the Learning Sciences*, 24(3), pp. 373-418.

### **PST1C36: 9:15-10:00 p.m. Vectors in Math and Physics Courses: An Instructional Gap**

Poster – Brian D. Farlow, North Dakota State University, 218 South Engineering, 1211 Albrecht Blvd., Fargo, ND 58108; brian.farlow@ndsu.edu

Chaelee Dalton, Pomona College

Warren M. Christensen, North Dakota State University

A research collaboration seeking to develop a research-based curriculum for a math methods course has found that upper-division physics students struggle with some vector concepts in non-Cartesian coordinate systems. The findings indicated a need to further explore what students are being taught about vectors and coordinate systems before they take courses such as intermediate mechanics and electromagnetism. An analysis of textbooks commonly used in Calculus III courses shows an overwhelming emphasis on Cartesian coordinates and mostly surface-level instruction, if any at all, about non-Cartesian coordinate systems (see Dalton et al). An analysis of commonly used textbooks in upper-division mechanics and E&M courses also reveals several gaps between how students learn about vectors and coordinate systems in math courses and how they are expected to use them in physics courses. We report on these gaps and discuss possible implications for instruction and curriculum design for physics courses.

### **PST1C37: 8:30-9:15 p.m. Views about Experimental Physics in a Large Introductory Laboratory Course**

Poster – Benjamin Pollard, University of Colorado Boulder, and JILA, Department of Physics, 390 UCB Boulder, Boulder, CO 80303; Benjamin.Pollard@colorado.edu

H. J. Lewandowski, University of Colorado Boulder, and JILA

Laboratory courses are key components of most undergraduate physics programs. In addition to reinforcing physics concepts, these courses often aim to achieve some or all of the following learning outcomes: developing students' experimental skills, engaging students in authentic scientific practices, and inspiring students' interest and engagement in physics. The Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS) is a research-based assessment that measures students' views about strategies, habits of mind, and attitudes when doing experiments in lab classes. During a complete transformation process of the large introductory laboratory course at the University of Colorado Boulder, we collected over 600 student responses per semester to the E-CLASS survey both before and after implementing the course transformation. We report on changes in E-CLASS responses before and after instruction from both the traditional and the transformed course.

### **PST1C38: 9:15-10:00 p.m. Visual Representations of Classroom Activity: What Captures the Essence?**

Poster – Adrienne L. Traxler, Wright State University, 3640 Colonel Glenn Hwy., Dayton, OH 45435-0001; adrienne.traxler@wright.edu

Eric Brewe, Kelley Commeford, Drexel University

Decades of evidence about science education show that a strict lecture format--or any other primarily transmissionist teaching style--is an ineffective way to learn. Researchers must now develop new vocabulary to move beyond simple dichotomies such as "lecture vs. active" and to describe the diversity of teaching practice. As an early step in this effort, we present observation data from the Classroom Observation Protocol for Undergraduate STEM (COPUS) gathered in a class using Tutorials in Introductory Physics. We contrast several representations of this data drawn from the literature, each of which highlights and obscures different features of classroom events. This work is part of a larger project to characterize several prominent active learning curricula in physics, build standardized profiles of their classroom activity, and connect these profiles to the student social network structures that emerge.

### **PST1C39: 8:30-9:15 p.m. Visualizing Changes in Conceptual Understanding Through Patterns in CSEM Responses**

Poster – Ryan C. Tapping, Cornell University, 142 Sciences Dr, Room E7 Clark, Ithaca, NY 14850; rct76@cornell.edu

G. Peter Lepage, Tomás A. Arias, N. G. Holmes, Cornell University

The Conceptual Survey of Electricity and Magnetism (CSEM) has been utilized to measure learning gains in electricity and magnetism (EM) physics courses, where students' overall scores on the CSEM are typically used for analysis. However, such comparisons do not identify particular content or concepts that are learned or misunderstood by students from the course. To address this issue, we have generated network-like graphs for each question, where responses at pre-test and post-test are represented by nodes connected with edges to display how student answers changed before and after instruction. We will present preliminary data from CSEM responses from over 1600 students in Cornell University's introductory EM physics courses across five years (10 semesters) of both traditional and active learning classrooms. We visualize and quantify patterns in responses showing how specific concepts are understood and applied by students, and what potential misconceptions may be prevalent even after instruction.

### **PST1C40: 9:15-10:00 p.m. Weekly Online Quizzes Outperform Written Quizzes**

Poster – David Pritchard, MIT, Room 26-241, Cambridge, MA 02139-4307; dpritch@mit.edu

Byron Drury, Sunbok Lee, Michelle Tomasik, MIT

Chandra Singh, U Pittsburgh

Starting with standard concept inventories by Singh and others, we created single topic online assessments taking ~½ hour by evening the coverage across subtopics, and including some questions requiring symbolic response. We administered these weekly along with ½ hour on-paper quizzes graded with partial credit in a remedial introductory mechanics course. Optimum reliability of the online quizzes occurred when weighting 1.0 (0.7) for first (subsequent) attempt correct. Both quiz averages correlated well with the traditional hand-graded long problems on the final exam (~0.8), and with the Mechanics Baseline Test online post-test (0.7) [1], but the online quizzes correlated much better with both the concept questions on the final exam and the Mechanics Reasoning Inventory [2]. We conclude that online quizzes are a better measure of overall student ability in mechanics, likely due to the combination of research-developed questions, selection of high discrimination questions, and absence of grading error.

### **PST1C41: 8:30-9:15 p.m. What Counts in Laboratories: Developing a Practice-based Identity Survey**

Poster – Kelsey M. Funkhouser, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824; kfunkh@msu.edu

Marcos D. Caballero, Paul W. Irving, Vashti Sawtelle, Michigan State University

An essential step in the process of developing a physics identity is the opportunity to engage in authentic physics practices. Physics laboratory courses are generally



structured as a place for students to gain experience with physics practices. This makes laboratory courses an ideal place to look at the impact these authentic science practices have on students' physics identity. As part of the development of a practice-based identity survey, we have interviewed students in a variety of physics lab classes, from intro algebra based to advanced lab, to gain insight into their interpretations of different commonly discussed practices. To ground our survey in students' experiences, we have asked questions about what these practices mean to the students. We present our findings on how students interpret these practices and situate themselves with respect to the practices as an indicator of their physics identity.

**PST1C42: 9:15-10:00 p.m. What Makes Instructional Development Teams Successful?**

Poster – Diana Sachmpazidi, Western Michigan University, 1903 Western Michigan Ave., Kalamazoo, MI 49008; ntiana.sachmpazidi@wmich.edu

Alice Olmstead, Charles Henderson, Andrea Beach, Western Michigan University

Team-based change efforts are a promising model for improving undergraduate STEM instruction. However, current literature on this topic is limited. To address this gap, we are investigating the characteristics of such teams. Our research focuses on understanding teamwork processes, which are closely tied to team outcomes. We will show our emerging framework that explains how structural and contextual factors influence team processes. This framework is based on interview data from project leaders and pilot data from team members for a subset of teams in our dataset. We will also explore team members' perspectives on, for example, how their team processes were established, the nature of their collaboration, and how conflicts that emerged during their work were resolved. We will show how these perspectives informed the initial framework developed primarily from interviews with project leaders. We will present recommendations for practitioners and researchers.

**PST1C43: 8:30-9:15 p.m. Who Declares a Physics Major? – A Study of Physics Pathways**

Poster – Cabot Zabriskie, 135 Willey St., Morgantown, WV 26506-0002; cazabriskie@mix.wvu.edu

John Stewart, West Virginia University

Most physics programs graduate very few students annually and improving these numbers is critical to both meeting societal needs for physics degree holders as well as for the long-term survival of physics departments. Understanding the pathways into, through, and out of a physics major is a necessary step toward improving retention of physics students to graduation. In this study, we investigate the demographic makeup of students at West Virginia University who have declared a physics major at any point in the past 15 years. In our analysis a number of distinct pathways are identified leading to multiple outcomes ranging from successful completion of a degree in physics to attrition out of the university. Categorization of these pathways and the properties of students who take each path can be used to adapt the physics program to the needs of students with different academic backgrounds and identify areas of program weakness.

**PST1C44: 9:15-10:00 p.m. Who Declares an Engineering Major – A Study of Engineering Pathways**

Poster – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506; stdevore@mail.wvu.edu

Cabot Zabriskie, John Stewart, West Virginia University

Engineering majors make up a large percentage of students moving through many introductory physics sequences. This being said, understanding the pathways that these students take to enter, exit, or maintain their path through engineering degree programs is an important step in increasing the number of STEM graduates generated. In this study, we examine 15 years worth of institutional data from one Eastern land-grant university to identify common pathways leading to successful degree completion, as well as departure from the engineering program. A better understanding of the commonalities of students on these pathways may lead to targeted interventions to prevent unnecessary departures from engineering programs.

**PST1C45: 8:30-9:15 p.m. Writing in Physics as a Mediator for Conceptual Change**

Poster – Antoinette Stone, University of California, Merced, 6695 Tiffany Cmn, Livermore, CA 94551; tstone3@ucmerced.edu

This poster reports the essay analysis of a targeted writing assignment, designed to examine how well physics students developed a more complex conceptual framework regarding models of friction and to the extent the task mediated critical thinking to achieve that framework. The assignment directed students to write an essay that examined the results of other student's misconceptions about friction, by reading research articles that reported classroom dynamics involving these students and their misconceptions. This study linguistically examines sentence structure and use of lexicon, to evaluate learning as modeled by conceptual change through negotiation of conceptual conflict and misconception.

**PST1C46: 9:15-10:00 p.m. Academic Performance of on-Campus and Online Physics Students**

Poster – John M. Long, Deakin University, School of Engineering, locked bag 20000, 75 Pigdons Road Geelong, VIC 3220 Australia john.long@deakin.edu.au

Purna C. Poudel, Deakin University

Online education in science has increased dramatically in the past 15 years. In spite of this, there are still relatively few online university physics courses. For 20 years, Deakin University in Australia has delivered physics education to engineering students both online and on-campus, two simultaneous sections of the same course: SEP101, Engineering Physics. We present a statistical analysis of the students' academic performance over a 20-year period. We examine all the assessment associated with the course – assignments, lab, and the exam, for over 4000 on-campus and online students. Overall, as far as numerical grades are concerned, we found no statistically significant difference between the academic performance of on-campus and online students. Some significant differences were observed in individual years. This work shows that in an introductory university physics course, it is possible to teach both on-campus and online students, producing the same learning outcomes for both cohorts.

**PST1C47: 8:30-9:15 p.m. Adaptation-Validation Inventory of Metacognitive Skills with Adolescents who Study Physics**

Poster – Oscar Jardey Suarez, Fundación Universidad Autónoma de Colombia, Calle 12 B No 4 - 21 Bogotá, AA 11001 Colombia oscar.jardey.suarez@gmail.com

Luz Divia Rico Suarez Secretaria de Educación de Bogotá

The main point of this article is to socialize the result of the adaptation and validation of the Metacognitive Awareness Inventory (MAI) to be used with adolescents who are studying physics in Middle School (High School) in Bogotá-Colombia. The MAI, initially proposed by Schraw & Denninson for youth and adults, is composed of two Supercategories: Knowledge of Cognition (Declarative Knowledge, Procedural Knowledge and Conditional Knowledge) and Regulation of Cognition (Planning, Organization, Monitoring, Debugging and Evaluation); another Super Category called affective (Anxiety) has been added. The expanded context of the MAI was focused on the area of physics, each item took its domain on a Likert scale between 1 and 7 and validation of statistical order was compared with the results of Huertas, Vesga & Galindo finding comparable values in the different super categories as well as their components, obtaining a total alpha of 0,941.

**PST1C48: 9:15-10:00 p.m. Algebraic Signs in Introductory Kinematics: A Redundant Educational Issue?**

Poster – Moa Eriksson, Uppsala University, Portalgatan 89, Uppsala, 75418 Sweden moa.eriksson@physics.uu.se

This poster reports on a case study involving 82 students drawn from Sweden and South Africa regarding how students think about, and consequently use, plus and minus algebraic signs in introductory-level kinematics. The results indicate that coming to appropriately understand the use of these signs presents a significant learning challenge to many students. The results are presented in terms of four qualitatively different categories, which are used to suggest there is a need for a new set of tutorials, which could be used to effectively enhance the functional understanding of the use of plus and minus algebraic signs in kinematics.

**PST1C49: 8:30-9:15 p.m. Archimedes Principle After 2268 Years**

Poster – Ajay Kumar Sharma, Fundamental PHYSICS Society, His Mercy Enclave Post Box 107 GPO Shimla 171001 HP INDIA shimla, HP 171001 India; ajoy.plus@gmail.com

Although Archimedes principle is confirmed, yet its qualitative applications in rising, falling and floating bodies in natural state (when no other forces than buoyancy and gravity act) are painstakingly analyzed. Here equations involve only densities of body and medium; and compared. Other factors like shape of body, viscosity of medium, magnitude of medium and body, surface tension etc. are neglected. In theoretical derivation of principle ( $u=VDg$ ), body is regarded as symmetric, there is no role of above factors. Under one feasible condition (when density of sheath, medium filled in floating artifact is equal to density of medium in which it floats), then volume of medium filled in artifact becomes indeterminate, from principle. If principle is generalized, i.e. upthrust is proportional to weight of fluid displaced,  $U=C VDg$ , then exact results are obtained. 'C' also accounts for elusive factors and can be confirmed in precise experiments.

**PST1C50: 9:15-10:00 p.m. Assessable Learning Objectives: Collaborative Development, Implementation, and Evaluation**

Poster – Charles M. Ruggieri, Rutgers, The State University of New Jersey, 136 Frelinghuysen Road, Piscataway, NJ 08854; chazr@physics.rutgers.edu

Debbie Andres, Paramus High School

Eugenia Etkina, Rutgers, The State University of New Jersey

Suzanne White Brahmia, University of Washington

Large enrollment physics courses for engineers at Rutgers include many components, with a team of faculty responsible for content. Course leaders change every few years and often modify materials based on their own experiences. To address this multifaceted and dynamic course administration environment, we initiated the Assessable Learning Objectives Project, which has helped inform the transformation of a large-enrollment calculus-based electricity and magnetism course. Faculty and PER researchers collaborated to construct learning objectives based on published goals from several sources. We analyzed course components (lecture, lab, workshop, quizzes, homework, and exams), determined in which components student engage with the desired objectives, and then coupled objectives with existing assessments to evaluate if the objectives are being met. In this poster, we address the learning objective development process, provide examples of assessable learning objectives, and discuss objectives that are not easily coupled with an assessment.

**PST1C51: 8:30-9:15 p.m. Assessing Students in Planning Investigation**

Poster – Hien Khong, Kansas State University, 1228 N 17th St., Manhattan, KS 66502-2525; hienkhong@ksu.edu

James T. Larverty, Kansas State University

Assessing students' learning plays an important role in education. The "Three-Dimensional Learning Assessment Protocol" (3D-LAP) has been introduced as a way to support the development of assessment tasks in physics that assess both the process and concepts of physics. Engaging students in planning investigations is an important practice in the process of physics that we need to assess. In order to figure out how to assess this scientific practice, we first identified the steps that go into planning investigations in physics. From this, we have identified the products that are observable in written assessments that could be used as evidence that students are able to plan investigations. We are using these observable products to design physics assessment tasks that align with the practice. This research will inform the development of new assessments focused on how well students can do physics, not just what they know about physics.

**PST1C52: 9:15-10:00 p.m. Assessing the Effectiveness of Enhancement in Content and Pedagogy Made to an Algebra-based Physics Course**

Poster – Sithy Maharroof, Carroll Community College, 1516 Touchard Drive, Baltimore, MD 21228; smaharroof@carrollcc.edu

There is an increasing need for teaching physics courses with the goal of helping students build multi-discipline scientific competencies. As part of fulfilling this need, a substantial amount of research has been done in 4-year institutions on transforming Introductory Physics for Life-Sciences (IPLS) courses to incorporate interdisciplinary content. However, there exists little to no information on the use of reformed IPLS courses in 2-year institutions. Hence my research focused on two 2-semester sequence of algebra-based physics courses at Carroll Community College. These courses serve students with life-science background and with a broad spectrum of career goals, such as physical therapy, sonography, nuclear medicine, MRI specialist, radiography, sports medicine, and pre-pharmacy. In this poster presentation, I will describe the designing, teaching, and assessing an IPLS model in the first of the two algebra-based physics courses described above, and I will share preliminary results from CLASS and FCI assessments along with several IPLS learning modules created as part of this project.

**PST1C53: 8:30-9:15 p.m. Assessment of Hybrid Flipped Classroom Teaching**

Poster – Steven Wild, University of Findlay, 1000 N. Main St., Findlay, OH 45840; wild@findlay.edu

Heather Yu, University of Findlay

Many instructors have adopted flipped classroom teaching to some extent. We have implemented in our introductory physics courses a hybrid flipped-lecture approach. Students in our class are required to watch videos for selected topics and complete an online quiz before coming to each class. Class periods consist of mini-lectures, which then provide students more time for questions and discussion. To assess the effectiveness of our hybrid flipped classroom teaching, we first compared the percentages of correct answers for questions with and without flipped teaching. Second, we track student responses to some similar questions at various points in a semester. Our findings about the effectiveness of flipped classroom teaching in preparing students for class discussions and in improving learning skills as well as retaining knowledge are presented.

**PST1C54: 9:15-10:00 p.m. Attitudes and Perceptions of Math Used in Physics-Intensive Careers**

Poster – Jessica Nicole Hathaway, Elizabeth City State University, 710 Oakdale Drive, Elizabeth City, NC 27909-9655; hathawayjessica18@gmail.com

Anne E. Leak, Erik Reiter, Kelly N. Martin, Benjamin Zwickl, Rochester Institute of Technology

Students' perceptions and attitudes toward math have been linked to physics identity and persistence in STEM, particularly in K-20 education, yet attitudes of new

employees in physics-intensive careers are less understood. We interviewed 25 new hires and managers to understand the attitudes and perceptions of mathematics done in physics workplaces. Using an emergent qualitative coding process and value coding we explored how employees valued math on the job, perceived the difficulty of math they used, and their confidence in their math abilities. Employees perceived the math they used as easy and were generally confident in doing math for their job, yet some perceptions reflected a fixed mindset toward learning math. These findings suggest that when math is embedded in a concrete physics context and is routinely used, learners may develop higher feelings of confidence and lower perceived difficulty than while learning mathematics in school.

**PST1C55: 8:30-9:15 p.m. Attitudes, Self-Efficacy, and Learning in Several Introductory Physics Tracks**

Poster – James R. Wu, Haverford College, 370 Lancaster Ave., Haverford, PA 19041; [bgeller1@swarthmore.edu](mailto:bgeller1@swarthmore.edu)

Catherine H. Crouch, Benjamin Geller, Swarthmore College

We examine survey data on student attitudes, self-efficacy, demographics, and learning in Swarthmore's three different introductory physics tracks (for life science students, engineers, and prospective majors). We report how these variables relate to student learning in these different contexts, with a particular focus on seeking beginning-of-semester information that might help identify students who are likely to struggle, and whether that information suggests any possible interventions. We also examine which students demonstrate improvements in attitudes and self-efficacy, and which stay the same or decline.

**PST1C56: 9:15-10:00 p.m. Beliefs and Performance: Male and Female Engineers in Introductory Physics**

Poster – Jennifer Blue, Miami University, 500 E Spring St., Oxford, OH 45056; [bluejm@miamioh.edu](mailto:bluejm@miamioh.edu)

Amy Summerville, Miami University

Brian Kirkmeyer, Miami University

As part of a larger study, we examined the effects of gender on performance and self-perception in a calculus-based physics course. This course is a prerequisite for our engineering majors and often proves to be a gatekeeper course for them. We surveyed students on their self-efficacy and their mindset, asked them about their exam scores, and then asked them about their affective and cognitive regret concerning their exams. Although self-reported exam scores were equivalent in each study, at times the beliefs of men and women differed. In Study 2, women had more of a growth mindset than men after the first exam. In both studies, men had higher self-efficacy at the start of the course, though the gap closed after the exams were returned in Study 2. And in Study 1, women reported more affective (but not cognitive) regret than men did.

**PST1C57: 8:30-9:15 p.m. Coulomb's Law: Not a One-on-One Game to Students**

Poster – David P. Maloney, Indiana University Purdue University - Fort Wayne, 2101 Coliseum Blvd., Fort Wayne, IN 46805; [maloney@ipfw.edu](mailto:maloney@ipfw.edu)

We investigated students thinking about the interaction of two positively charged objects when other charges or objects were introduced between them. We constructed a sequence of five tasks where a variety of spherical shells were placed around one of the two charged objects. The students were asked to compare each variation to the base case on the push one of the positively charged objects exerted on the other. We pre-tested and post-tested students in an algebra-based college general physics course and found that the majority of the students think the interaction between two charges changes when external objects are around. We found clear patterns in the way students thought about the different variations. And we were able to identify several common mechanisms the students think are responsible for the changes. Instruction was found to produce only a moderate change in students' thinking.

## Pre-college/Informal and Outreach

**PST1D01: 8:30-9:15 p.m. Physics of Paper Helicopter**

Poster – Gyaneshwaran Gomathinayagam, The Doon School, Mall Road, Dehradun, India 248001 India; [gya@doonschool.com](mailto:gya@doonschool.com)

Bhuvan Verma, McGill University, Desautels

Aayush Chowdhry, The Doon School

A paper helicopter was constructed using a standard A4 sheet of paper. When a paper helicopter is dropped from a height, it rotates while falling down and quickly attains terminal velocity. Its mass was varied by wrapping duct tape around the bottom stem of the helicopter. The effect of mass of the helicopter on the terminal velocity, terminal angular velocity, and time taken to achieve the terminal velocity were studied. Terminal velocity squared, terminal angular velocity, and the time taken to achieve terminal velocity were found to vary linearly with mass. A simple explanation is provided to explain how the direction of folding of the helicopter blades determines whether the paper helicopter will rotate clockwise or anti-clockwise after being dropped.

**PST1D02: 9:15-10:00 p.m. Project Accelerate: Closing the Access Gap for STEM Careers and Academic Programs\***

Poster – Andrew G. Duffy, Boston University, Department of Physics, Boston, MA 02215; [aduffy@bu.edu](mailto:aduffy@bu.edu)

Mark D. Greenman, Boston University

Boston University is in the first year of implementing a three-year NSF DRK12 award bringing AP Physics 1 to underserved populations. During our prior pilot year, Project Accelerate partnered with 11 high schools in Massachusetts and West Virginia to bring a College Board approved Advanced Placement\* Physics Small Private Online Course (SPOC) to schools not offering this opportunity to students. Project Accelerate students (1) outperformed peer groups in traditional AP Physics classrooms on the College Board AP Physics exam, and (2) were more inclined to engage in additional Science, Technology, Engineering and Mathematics (STEM) programs than they were prior to participating in Project Accelerate. Through the NSF award, we look at scaling up and replicating this program, potentially on a national scale. The poster will highlight the project research questions, methodology, implementation strategy, and pilot-year outcomes. Project Accelerate offers a replicable solution to a significant problem – too few underserved high school students having access to high quality physics education, resulting in these students being ill prepared to enter STEM careers and STEM programs in college.

\*Funded by NSF grant DRL 1720914.

**PST1D03: 8:30-9:15 p.m. Refugees Exploring the Foundations of Undergraduate Education in Science (REFUGES)**

Poster – Tino Nyawelo, University of Utah, Department of Physics & Astronomy, JFB # 201, 115 South 1400 East, Salt Lake City, UT 84112; [tnyawelo@gmail.com](mailto:tnyawelo@gmail.com)

Jordan Gerton, University of Utah

REFUGES is a robust STEM-focused refugee and minority student support program, which has two distinct components: 1) an afterschool program for refugee and immigrant students (grades 7-12) that provides academic support, hands-on science enrichment, and social services such as family counseling, health and wellness

workshops, and recreational activities; and 2) a bridge program for incoming University of Utah students from marginalized populations to adjust to college life, course work and research. During the summer, participating students live on campus for seven weeks and complete two courses that count towards University of Utah undergraduate degree requirements and prepare students for success in STEM. It also offers research lab placement positions to students during student's freshman years. This experience launches interaction with peers, graduate students, and faculty and helps students develop a network of colleagues who will help them throughout their academic careers.

**PST1D04: 9:15-10:00 p.m. Rolling Resistance Coefficient and Air Pressure Inside a Football**

Poster – Gyaneshwaran Gomathinayagam, The Doon School, Mall Road, Dehradun, India 248001 India gya@doonschool.com

Siddhant Singhania The Doon School

A football at different internal pressures was rolled from rest down an inclined smooth wooden plank. The acceleration of its centre of mass was measured by video analysis using TRACKER software. It was found to increase with excess pressure inside the football until it reached a constant value at an excess pressure of 36.43 kPa and above corresponding to a minimum constant value of rolling resistance. The decrease in the acceleration at lower pressures was linked to the increase in contact area of the football, which resulted in greater hysteresis energy loss due to the deformation of the football while rolling. This was modelled by defining rolling resistance coefficient  $S_r$  as the offset distance of the line of action of the normal reaction producing a retarding torque on the football.  $S_r$  was found to be an inverse exponent function of excess pressure.

**PST1D05: 8:30-9:15 p.m. The PISEC International Summer Camp: A New Global Outreach Initiative**

Poster – Michael B. Bennett, University of Colorado Boulder, 440 UCB, Boulder, CO 80309; michael.bennett@colorado.edu

Claudia Fracchiolla, University College Dublin

It is an important time for the public face of physics. A number of scientific bodies have highlighted the importance not only of engaging the public's interest in physics but in reaching out to diverse populations while doing so. Thus, outreach programs focusing on empowering and enabling traditionally under-represented populations have a huge part to play in the inclusion and enculturation of future generations of scientists. CU Boulder's Partnerships for Informal Science Education in the Community outreach program has partnered with NUI Galway to create a multisite outreach initiative with a unique focus on international, realtime collaboration. Children from diverse geographic locations will work together to solve physics problems, creating an environment facilitating both content and practice learning while expanding their frontiers and engaging in cross-cultural interactions. The program's goals and execution will be discussed, as well as exciting opportunities for global implementation.

**PST1D06: 9:15-10:00 p.m. The Pulsar Search Collaboratory – A Citizen-Science Program**

Poster – John C. Stewart, West Virginia University, 135 Willey St. - White Hall, Morgantown, WV 26506; jcstewart1@mail.wvu.edu

Kathryn Williamson, Cabot Zabriskie, West Virginia University

The Pulsar Search Collaboratory is a citizen-science program to engage middle and high school student in radio astronomy. The project reserves a set of radio astronomy data for the students that has not been examined by scientists. The students receive online training in radio astronomy, pulsar science, and the identification of pulsars. The students then examine plots of radio astronomy data to determine whether the data represents an unknown pulsar. Over 2 million pulsar plots have been scored resulting in the discovery of eight new pulsars; a significant scientific discovery. Students and participating teachers are eligible to be invited to summer camp at the Green Bank Observatory home to the world's largest fully steerable radio telescope.

**PST1D07: 8:30-9:15 p.m. The Science Theatre Program**

Poster – Patrick R. Morgan, Michigan State University, 755 Science Rd., East Lansing, MI 48824; morgan@pa.msu.edu

Science Theatre is a unique science outreach program at Michigan State University. A nonprofit organization, Science Theatre is run by undergraduate students. It is also a registered student organization at MSU, and funded by the Physics and Astronomy department. Science Theatre visits over 100 schools and events throughout the state of Michigan every academic year, reaching over 30,000 k-12 students annually. They offer dramatic stage presentations, as well as hands-on demonstrations, to schools at no charge. They manage to do all of this while spending less than 20 cents per child. Come to this poster session to learn more, including how to start a Science Theatre program in your state.

**PST1D08: 9:15-10:00 p.m. Transforming the Relationship between Practice and Research in Informal Science Programs\***

Poster – Claudia Fracchiolla, University College Dublin, 247 Laurel Park, Galway, KS H91 TN2H; Ireland claudiafracchiolla@yahoo.com

Michael Bennett, University of Colorado Boulder

Kathleen Hinko, Michigan State University

There is a disconnect between practice and research in informal physics programs. The majority of informal physics programs engage only in evaluation, focusing on numbers of participants, time spent interacting, learning outcomes, or level of audience engagement, etc. Assessment may not exist or come only as an afterthought, once the program has already been designed and implemented. Another assessment-related challenge is that practitioners lack the proper training or tools to engage in research in these complex environments. We propose design-based implementation research (DBIR) as a solution to these challenges. DBIR practitioners collaborate with broad groups of stakeholders to create a shared understanding of local contexts, using implementation evidence to iteratively design the innovation, thereby addressing local needs and conditions. In response to the call of physics teachers in Kenya, we have developed a workshop where practitioners and researchers work together to create strategies and resources for designing locally-realized informal programs. We present here outcomes of the workshop, including participant-created programs, as well as participants' perceptions of gains after participation.

\*This study has been possible in part Thanks to the Institute of Physics Ireland and the Mawazo Institute.

**PST1D09: 8:30-9:15 p.m. Toppling Time of Dominoes in Circular Arrangements of Different Radii**

Poster – Gyaneshwaran Gomathinayagam, The Doon School, Mall Road, Dehradun, India 248001 India gya@doonschool.com

Lakshman Santhanam, The Doon School

20 identical wooden blocks were arranged as dominoes with equal spacing in circles of different radii to cover the full range of possible separation. Their toppling times were recorded by video analysis using TRACKER software and it was found to be an exponential function of the radius of the circle. The time interval between each collision in the circular chain of dominoes was compared for different radii of circular arrangements. It was found that the total toppling time could be com-

puted as the sum of toppling times of five distinct stages in the toppling sequence. The fourth stage (toppling time for blocks 5 to 19) showed the maximum variation with radius of circle whereas the other stages had similar times for different radii.

### **PST1D10: 9:15-10:00 p.m. Using Champions to Help Bring Cultural Awareness to K-12 Physics**

Poster – David Rosengrant, University of South Florida St. Petersburg, 140 7th Avenue South, Coquina 201, St. Petersburg, FL 33701; [rosengrant@mail.usf.edu](mailto:rosengrant@mail.usf.edu)  
Gregory Rushton, Stony Brook University

Data shows that in physics, especially the teacher workforce, we find a very non-diverse group of individuals (mostly white males). Though this trend is slowly changing, the challenge is evident that we need to be proactive now in encouraging more women and individuals who are not white to study physics. What is also important is that we do this in a way that normalizes the idea of diversity in physics. This project focuses on ways we can bring that conversation into a normal routine by highlighting what we term as Physics Champions. Since many teachers are resistant to broad changes in curriculum due to time commitments or other reasons, I provide the key materials ready for teachers to implement this strategy seamlessly into their curriculum. It only takes minutes and can be used as often as teachers want to use it. Practicing teachers have already found this to be impactful.

### **PST1D11: 8:30-9:15 p.m. Active Learning in High School Physics Lessons in Japan**

Poster – Sachiko Tosa, Niigata University, 8050 banchi, 2-no-cho, Nishi-ku, Niigata, Niigata 950-2181 Japan [stosa@ed.niigata-u.ac.jp](mailto:stosa@ed.niigata-u.ac.jp)  
Ryuichi Minami, Niigata University

In this study, Japanese high-school physics lessons (N=10) are examined in terms of how actively students participate in the lesson. The following three methods are used for analyzing the data: 1) levels of teacher questions using Bloom's taxonomy, 2) levels of interactions between students and teacher, and 3) shape of S-T graph which shows who directs the lesson. The results indicate that Japanese high school physics lesson often do not include solid lesson structures, and multiple topics are covered didactically by the teacher in one-way transmission of information. In this presentation, a model of active-learning style lessons for high-school physics is proposed. The model is developed based on the findings in physics education research and in action research when it is actually implemented in a high school classroom. The effectiveness of the model will be shown as preliminary data.

### **PST1D12: 9:15-10:00 p.m. Identity in STEAM: Building Physics Identities through Performance**

Poster – Simone A. Hyater-Adams, University of Colorado at Boulder, 390 UCB, Boulder, CO 80309; [simone.hyateradams@colorado.edu](mailto:simone.hyateradams@colorado.edu)  
Tamia William, Mount Holyoke College  
Claudia Fracchiolla, University College Dublin  
Noah Finkelstein, University of Colorado Boulder  
Kathleen Hinko, Michigan State University

Educational programs that integrate the arts and sciences, or STEAM, are growing in prominence within the informal education sphere. However, there is still work to be done on understanding what these programs do for students. We begin to answer to this question through an examination of identity. With the broad research goal of understanding physics identity for Black students, we explore the potential for informal STEAM educational spaces to plant the seeds of physics identity through the use of pedagogies and activities that incorporate dance and theater. We present findings from a study where Black physicists were asked about how their participation in the arts impacted their physics identities. These findings show that the performing arts played several different roles in these physicists lives. Here, we present the ways that these themes map onto potential structures, pedagogies, and norms in an informal physics and performance program for youth.

### **PST1D13: 8:30-9:15 p.m. Physics as Moral Education: Take it Beyond Content Knowledge**

Poster – Stephen March, Washington International School, 3100 Macomb St. NW, Washington, DC 20008; [steve.march@wis.edu](mailto:steve.march@wis.edu)

We are teaching in a time when high school science courses are required to pack in more and more content. While this may serve to advance knowledge in the sciences, it makes it more difficult to engage students in dialogue about the moral implications of applying the knowledge. Physics courses provide an excellent opportunity for dialogue and reflection and teachers should be aware of the opportunities and ready to engage students. This poster identifies areas across the physics topics that make good entry points for dialogue and provides question frames for engaging students.

## **Teacher Training/Enhancement**

### **PST1E02: 9:15-10:00 p.m. Pre-service Physics Teachers' Beliefs in the Context of Reflective Practice Activities**

Poster – Sungmin Im, Daegu University, 201 Daegudae-ro, Dept. of Physics Education, Gyeongsan, Gyeongsangbukdo 38453 South Korea; [ismphs@daegu.ac.kr](mailto:ismphs@daegu.ac.kr)

The purpose of this study is to investigate pre-service physics teachers' beliefs about teaching and learning physics in the context of reflective practice activities. For this, the author designed the reflective practice activities for pre-service physics teachers according to the pedagogy of the reflective teacher education model based on previous literature, and 33 pre-service physics teachers took part in this reflective practice where pre-service teachers should reflect on their teaching plans and practices for five weeks before field practicum. In this study beliefs about teaching and learning physics consists of two constructs; epistemological belief and self-efficacy belief. To measure pre-service physics teachers' beliefs the author utilized Belief About Learning Physics Survey (BAPS) and a modified Science Teaching Efficacy Belief Instrument (STEBI). As a result, the author found the distribution of the pre-service physics teachers' beliefs and compared them according to their reflective thinking profiles.

### **PST1E03: 8:30-9:15 p.m. Recruiting Future Physics Teachers with a Summer Enrichment Program**

Poster – AJ Richards, The College of New Jersey, 2000 Pennington Rd., Ewing, NJ 08628; [aj.richards@tcnj.edu](mailto:aj.richards@tcnj.edu)  
Nathan Magee, Lauren Madden, Marissa Bellino, Melissa Chessler, The College of New Jersey

The shortage of well-qualified physics teachers is a crisis on a national scale. To address this issue, our institution has successfully applied for a Robert Noyce Teaching Scholarship grant. As part of the programming we've developed from the grant support, we have created a field-based summer enrichment program designed to encourage current students (not on the educational track) to consider transferring to our physics teacher-prep major. The Summer Teacher Exploration Program for Undergraduate Physics (STEP-UP) is a three-week program that gives students a crash course in pedagogy and learning sciences and then allows them the opportunity to design and actually teach lessons in local K-12 classrooms. In this presentation we will describe STEP-UP in detail and discuss how the program changed

participants' views on teaching and its viability as a future career path.

**PST1E04: 9:15-10:00 p.m. Characterizing Next Gen PET Assessments Using the 3-D LAP**

Poster – Meghan P. Clemons, Tennessee Technological University, P.O. Box 5051, Cookeville, TN 38505; mpengland21@students.tntech.edu

Stephen Robinson, Paula Engelhardt, Tennessee Technological University

The Three-Dimensional Learning Assessment Protocol (3-D LAP) (1) was developed to evaluate the alignment of summative assessment items used in college science courses with the three dimensions of the Next Generation Science Standards (NGSS). We have adapted the 3-D LAP for use in characterizing items specifically developed for use with the Next Generation Physical Science and Everyday Thinking (Next Gen PET) (2) materials. We will discuss how the protocol was adapted to fit the needs of these mostly conceptual materials and give examples of items with different degrees of dimensionality. We will also show examples of how items can be changed to address multiple dimensions. Eventually the aim of this work is to develop a protocol to assist instructors in developing their own NGSS-aligned assessment items.

(1) Laverty, J. T., et. al., (2016). PLoS ONE,11(9): e0162333. (2) <http://nextgenpet.iat.com>

**PST1E05: 8:30-9:15 p.m. Teachers' Energy Model as a Tool for Interpreting Student Ideas in a Community of Practice\***

Poster – Orlala T. Wentink, 3307 3rd Ave W Suite 307, Seattle, WA 98119; owentink@spu.edu

Amy D. Robertson, Seattle Pacific University

The Physics Department at Seattle Pacific University supports a group of highly engaged elementary school teachers in a professional learning community (PLC) focused on student learning about energy. Using the lens of communities of practice, we are analyzing video episodes from these PLC meetings to try to understand what supports the teachers' mutual engagement in their joint enterprise of reformed science teaching. In this talk, we illustrate that their co-constructed model of energy is a tool in the teachers' shared repertoire and supports their mutual engagement in reformed science teaching. We highlight the role that this tool plays in the teachers' interpretation of student ideas.

\*Supported in part by NSF Grant No. 1418211

**PST1E06: 9:15-10:00 p.m. Comparing Physics Teacher Preparation in Canada, China, Germany, and NY**

Poster – Daniel MacIsaac, SUNY Buffalo State College Physics, SAMC278, 1300 Elmwood Ave., Buffalo, NY 14222; macisadl@buffalostate.edu

Weining Wu, Hubei University China

Kathleen Falconer, Universität zu Köln

Richard Hechter, University of Manitoba

We juxtapose, compare and contrast standard physics teacher preparation programs from Manitoba Canada, Hubei China, Cologne Germany, and Buffalo, NY USA. Program lengths and scopes, admissions criteria, physics and education course content and durations, field work, student teaching, state exams, graduation requirements are briefly described. Commonalities are described and discussed. Notable features and brief comments on strengths and weaknesses are proffered by experienced faculty associated with programs from all four locations.

**PST1E07: 8:30-9:15 p.m. Evolution of Reflective Skills of Pre-service Physics Teachers**

Poster – Marianne Vanier, Rutgers University, 10 Seminary Place, New Brunswick, NJ 08901-1267; mmdvanier@gmail.com

Eugenia Etkina, Rutgers University

The poster will show the patterns that emerged from our analysis of pre-service teachers' reflections while they acquire additional teaching experience in an ISLE-reformed introductory physics course for science students. The teaching occurred before and after the formal student teaching internship. We were interested in the changes in the pre-service physics teachers' reflections (content, emergent themes, theme evolution etc.) as they can be indicators of professional development as well as awareness of the role that science practices play in learning physics. Over 300 reflections were coded using a validated coding scheme.

**PST1E08: 9:15-10:00 p.m. Exploring One Aspect of Pedagogical Content Knowledge of Physics Instructors and Teaching Assistants Using the Force Concept Inventory\***

Poster – Alexandru Maries, University of Cincinnati, 3405 Telford St., Cincinnati, OH 45220; mariesau@ucmail.uc.edu

Chandralekha Singh, University of Pittsburgh

The Force Concept Inventory (FCI) has been widely used to assess student understanding of introductory mechanics concepts by a variety of educators and physics education researchers. One reason for this extensive use is that many of the items on the FCI have strong distractor choices that correspond to students' alternate conceptions in mechanics. Instruction is unlikely to be effective if instructors do not know the common alternate conceptions of introductory physics students and explicitly take into account students' initial knowledge state in their instructional design. Here, we discuss research involving the FCI to evaluate one aspect of the pedagogical content knowledge of both instructors and teaching assistants (TAs): knowledge of introductory student difficulties related to mechanics as they are revealed by the FCI. We used the FCI to design a task for instructors and TAs that would provide information about their knowledge of common student difficulties and used FCI pre-test and post-test data from a large population (~900) of introductory physics students to assess this aspect of pedagogical content knowledge of physics instructors and TAs. We find that while both physics instructors and TAs, on average, performed better than random guessing at identifying introductory students' difficulties with FCI content, they did not identify many common difficulties that introductory physics students have, even after traditional instruction. Moreover, the ability to correctly identify students' difficulties was not correlated with the teaching experience of the physics instructors or the background of the TAs. \*Work supported by the National Science Foundation

**PST1E09: 8:30-9:15 p.m. Exploring One Aspect of Pedagogical Content Knowledge of Teaching Assistants Using the Test of Understanding Graphs in Kinematics\***

Poster – Alexandru Maries, University of Cincinnati, 3405 Telford St., Cincinnati, OH 45220; mariesau@ucmail.uc.edu

Chandralekha Singh, University of Pittsburgh

The Test of Understanding Graphs in Kinematics (TUG-K) is a multiple choice test developed by Beichner in 1994 to assess students' understanding of kinematics graphs. Many of the items on the TUG-K have strong distractor choices which correspond to students' common difficulties with kinematics graphs. We evaluate

one aspect of the pedagogical content knowledge of first year physics graduate students enrolled in a teaching assistant (TA) training course related to topics covered in the TUG-K. We used the TUG-K to design a task for TAs that would provide information about their knowledge of common student difficulties and used the TA data and the data from Beichner's original paper for introductory physics students (which was collected from over 500 college and high-school students) to assess this aspect of the pedagogical content knowledge (PCK) of the graduate students, i.e., knowledge of student difficulties related to kinematics graphs as they are revealed by the TUG-K. We find that, although the graduate students, on average, performed better than random guessing at identifying introductory student difficulties on the TUG-K, they did not identify many common difficulties that introductory students have with graphs in kinematics. In addition, we find that the ability of graduate students to identify the difficulties of introductory students is context dependent and that discussions among the graduate students improved their understanding of student difficulties related to kinematics graphs. Moreover, we find that the ability of American graduate students in identifying common student difficulties is comparable with that of foreign graduate students.

\*Work supported by the National Science Foundation.

### **PST1E10: 9:15-10:00 p.m. Incorporating New Materials, Content and Pedagogy in Professional Development Workshops**

Poster – Aaron Wangberg, Winona State University, 322 Gildemeister Hall, Winona, MN 55987; awangberg@winona.edu

Elizabeth Gire, Oregon State University

Robyn Wangberg, Saint Mary's University of Minnesota

Instructors are often attracted to the Raising Physics and Raising Calculus materials because they provide a new way for students to engage with physical and mathematical content. The materials help students share discoveries before formal lecture, and while instructors in the professional development workshops are often thrilled about the new perspective on content, they are often equally awed by the changes in teaching practices and expectations that accompany the tools. In this poster, we will share our own discoveries and lessons -- some learned painfully -- for helping instructors broaden their own teaching practices and incorporate student ideas into the classroom.

### **PST1E11: 8:30-9:15 p.m. Initiating Meetings of Local Physics and Physical Science Teachers**

Poster – Daniel M. Crowe, Loudoun Academy of Science, 21326 Augusta Dr., Sterling, VA 20164; dan.crowe@lcpa.org

Most high school physics teachers face many barriers to attending national meetings of professional societies. The cost of attending meetings and the inconvenience of travel are difficult to justify if it is unclear what, if any, benefits there are to meeting with colleagues. This school year, I started organizing meetings of high school physics teachers and middle school physical science teachers in Loudoun County, VA, where I teach. Such local meetings introduce participants to the benefits of meeting with physics colleagues for professional development while minimizing time commitments and expenses. I will report on the activities in which we engaged, the difficulties we encountered, and suggestions for others wishing to organize local meetings in their communities.

### **PST1E12: 9:15-10:00 p.m. Integrating Computation: What's New from PICUP\***

Poster – Larry Engelhardt, Francis Marion University, 4822 E. Palmetto St., Florence, SC 29506; lengelhardt@fmarion.edu

Kelly Roos, Bradley University

Marie Lopez del Puerto, University of St. Thomas

Danny Caballero, Michigan State University

Norman Chonacky, Yale University

The purpose of this poster is to provide some updates about exciting opportunities that are available to you from “PICUP” (the “Partnership for Integration of Computation into Undergraduate Physics”). These opportunities include week-long workshops during the summer, single-day workshops at AAPT meetings and at various locations around the country, and editable curricular materials that can be downloaded from the PICUP Collection of the ComPADRE Digital Library: [www.compadre.org/PICUP](http://www.compadre.org/PICUP). Do you already integrate computation into your courses? If so, you should submit your materials for publication in the PICUP Collection, which gives you the opportunity to both (1) contribute to the broader physics community, and (2) get some peer-reviewed publications in the process!

\*This project is funded by the National Science Foundation under DUE IUSE grants 1524128, 1524493, 1524963, 1525062, and 1525525.

## **Technologies**

### **PST1F01: 8:30-9:15 p.m. Physics Mastery Modules: An Open First-Year Physics Learning System**

Poster – Joseph D. MacMillan, University of Ontario Institute of Technology, 2000 Simcoe Street North, Oshawa, ON L1H 7K4, Canada; joseph.macmillan@uoit.ca

Rupinder Brar, University of Ontario Institute of Technology

In many introductory university courses, including physics, online homework systems have mostly replaced traditional hand-written assignments; however, the most common online systems are provided by textbook publishers, which can be expensive and inflexible. Using the results of education research, we identified a “mastery setting” as a good model for homework delivery. In an effort to improve effectiveness and eliminate cost of online homework assignments at the first-year level of all physics courses at the University of Ontario Institute of Technology (UOIT), we built an online open-education learning system entitled Physics Mastery Modules. In this poster we will describe this initiative, as well as quantify the statistically significant improvements in student performance and engagement.

### **PST1F02: 9:15-10:00 p.m. VPython Coding Challenges for Calculus-based Physics**

Poster – Glenda Denicolo, Suffolk County Community College, 533 College Road, Selden, NY 11784; denicog@sunysuffolk.edu

The VPython coding challenges I use in my calculus-based physics classes are available for public use. These codes are minimal working examples where students build from to calculate physical quantities, create visualizations, and make the necessary plots to understand motion. Sometimes only a few changes to the initial code are necessary. When more is required, students are guided by comments contained in the codes, which also have questions to be answered. Videos are provided to show a possible solution to each challenge. The codes are deployed with trinket.io. In mechanics, the topics are: one-dimensional motion, projectile motion at complementary angles, Newton's second law with air drag, examining elliptical versus circular orbits, energy and momentum of a bouncing ball, two-dimensional collision, center of mass motion in a collision, angular momentum conservation in orbital motion, simple harmonic oscillator, damped and driven oscillators, superposition of waves. The coding challenges are available at: <http://gdenicolo.net/vpython.html>

**PST1F03: 8:30-9:15 a.m. WorldWide-Telescope-based Data Visualization and its Educational Application**

Poster – Cuilan Qiao, \* Central China Normal University, No.152, Luoyu Road, Hongshan District, Wuhan, China 430079 China; qcl@mail.ccnu.edu.cn

Chenzhou Cui, National Astronomical Observatories of China

Hongguang Wang, Guangzhou University

Yunwei Yu, Central China Normal University

Lin Ding, The Ohio State University

Scientific data typically is presented in the form of standardized charts or diagrams, which are not easily accessible for the public. Conversely, information aimed at the general public often is transmitted through visual images, videos, and educational texts and therefore is more user friendly. Based on the large dataset platform named WorldWide Telescope, we have designed various instructional activities to engage Chinese university students in scientific experiences, such as processing and visualization of authentic data of seismic zones, gamma ray bursts, pulsars, binary stars, ancient Chinese constellations, satellites and their orbits. The activities transform abstract scientific data into concrete, 3-D visual information, suitable for educational purposes. The process of visualization can also enhance students' understanding of scientific knowledge. We discuss the design and implementation of the WWT-based visualization and explore its application for cultivating scientific skills among our next generation of STEM workforce.

\*Sponsored by Lin Ding

**PST1F04: 9:15-10:00 p.m. 2-D Collisions Experiment Using Local Positioning Technology**

Poster – Paul R. DeStefano, Portland State University, P.O. Box 751, Portland, OR 97201-0751;; paul.destefano-aapt@vfemail.net

Cora Seibert, Thomas Allen, Ralf Widenhorn, Portland State University

The advent of low-cost local positioning systems provides a new opportunity for introductory physics laboratory activities. Using this technology, students can obtain position data for two-dimensional collisions, while at the same time measure acceleration and rotational speed. These data sets are of sufficient quality that students can analyze trajectories before and after the collision to verify the law of conservation of momentum, even when collisions involve the transfer of angular momentum. Local positioning offers more complexity and “real-world” applicability than is achievable by the traditional one dimensional collision experiments of two carts on a track.

**PST1F05: 8:30-9:15 p.m. A Controlled Study of Stereoscopic Virtual Reality in Freshman Electrostatics**

Poster – Christopher D. Porter, The Ohio State University, 2466 E Livingston Ave., Bexley, OH 43209; porter.284@osu.edu

Chris Orban, The Ohio State University (Marion campus)

Joseph Smith, The Ohio State University

Amber Simmons, Megan Nieberding, The Ohio State University

The incorporation of virtual reality (VR) into instruction has been difficult due to high-cost headsets or “caves,” and the challenge of serving an entire student population with only one or a few such devices. This has changed with the advent of smartphone-based stereoscopic VR. Inexpensive cardboard headsets and smartphones already in students' pockets are the only elements needed for a virtual reality experience. We have studied the utility of VR visualizations (in some cases with introductory training) in the context of Gauss's law and electrostatics in a cohort of students in calculus-based introductory physics at The Ohio State University. By recording the orientation of the smartphones during some visualizations, we have also tracked and mapped student perspectives, giving us a proxy for student attention to various details. Although data are preliminary in this growing study, we comment on possible reasons for differences among student groups.

**PST1F06: 9:15-10:00 p.m. Using a Smartphone to Teach Physics Concepts**

Poster – Minjoon Kouh, Drew University, 36 Madison Ave., Madison, NJ 07940-1493; mkouh@drew.edu

Andrew Goldstein, Drew University

Today's smartphone is a versatile, little machine. It contains a variety of sensors that constantly monitor the state of the phone and its environment. We used linear accelerometer in a smartphone to supplement lessons from introductory mechanics. In particular, we developed 30-minute physics activities for illustrating the Cartesian coordinate system, for distinguishing velocity and acceleration concepts, and for performing vector decomposition. We also did a survey on the perceived usefulness and quality of experience for these physics activities.

**PST1F07: 8:30-9:15 p.m. BuckeyeVR 3D Plot Viewer – A Free Resource for Smartphone-based VR\***

Poster – Chris Orban, 191 W Woodruff Ave., Columbus, OH 43210; orban@physics.osu.edu

Chris Porter, Joseph Smith Ohio State University

Although there are a number of smartphone apps that can produce interesting stereoscopic visualizations using a cheap VR viewer (often called Google Cardboard), until recently there did not exist a resource to allow STEM educators to use this VR technology to display user-defined functions, curves, and vector fields. The BuckeyeVR 3D plot viewer is a free resource that allows educators to both render a user-defined function in a web interface and to quickly view this function in stereoscopic 3D using smartphone-based VR. This is made possible by a freely available smartphone app for Android and iPhones that can take information from the web interface and reproduce the visualization on the smartphone. This resource is available at buckeyevr.osu.edu and we encourage STEM educators to adopt it and to collaborate with Ohio State in examining the pedagogical benefits of this technology.

\*Funding from OSU internal sources including the STEAM factory.

**PST1F08: 9:15-10:00 p.m. Framework for Teaching with Historical Primary Sources in Science Classrooms**

Poster – John F. Smith, Northwestern University, 2120 Campus Drive, Room 201, Annenberg, Hall Evanston, IL 60208; jfsmith@u.northwestern.edu

Digitized primary sources, from manuscripts and maps to patents and photographs, are increasingly available for classroom use. These documents can illustrate how models and explanations of phenomena in physics, physical science, and astronomy have changed over time. Additionally, primary sources can shed light on the practices and lives of scientists. Beyond being windows into science content and practices, primary sources can open up questions about the ways in which technologies and the sciences intersect with community challenges that have roots in our past and demand attention in our present.



# High School Share-a-Thon



## Show and Tell!

*Not for HS teachers only!*

**Note Time!**

**Monday, 8:30-10 p.m.  
Meeting Room 8/9**

Tuesday Morning

## 8:00–9:00 a.m. Tuesday, July 31: SPS – Best Practices for Conducting Outreach — Meeting Room 16

*Brad Conrad*

Communicating science to the public is pivotal for scientific literacy and can help promote public understanding of physics education and research. Undergraduate students have a unique position to foster a curiosity and passion for the physical sciences within the next generation. In this session, participants will learn the ins and outs of planning and implementing quality outreach programs while exploring a variety of interesting outreach demonstrations. Hosted by the Society of Physics Students, this session will provide undergraduates the tools necessary to help students of all ages explore physics and astronomy concepts.

**DA01: 8:30-8:40 a.m. Do Students Buy-in to Studio Physics Classes?: Survey Analysis***Contributed – Matthew Wilcox, University of Central Florida, 4111 Libra Dr., Orlando, FL 32816; mwilcox1@knights.ucf.edu**Jacquelyn J. Chini, University of Central Florida*

In studio physics classes, instructors may use reformed instructional strategies that students might not expect when they register for the class. As a result, instructors might experience student resistance to these strategies, and that resistance may discourage their continued use of the research-proven strategies. We hypothesize that instructors could reduce student resistance through discussions with students about expectations for the class format and why students should agree with the format. We are investigating how well students agree with the studio format, how their agreement affects their performance in class, and what instructors do to gain student agreement. Two surveys were created that measure student agreement and instructor methods to achieve student agreement. We report on the results of these surveys, finding that student agreement varies greatly within a class but is fairly consistent across physics classes. Additionally, we find that instructors tend to use student-centered methods to discuss student-centered activities.

**DA02: 8:40-8:50 a.m. Impact of Evidence-based Pedagogies on Student Performance in Introductory Physics***Contributed – Nafis I. Karim, University of Pittsburgh, 3941 O'Hara St, Allen Hall, Pittsburgh, PA 15260; nik49@pitt.edu**Alexandru Marius, University of Cincinnati**Chandrulekha Singh, University of Pittsburgh*

We compare student performances in courses which use evidence-based active engagement (EBAE) strategies with courses that primarily use lecture-based (LB) instruction. We used FCI in the first semester and CSEM in the second semester to assess students' conceptual understanding. The performance of students in EBAE courses is compared with those in LB courses in two situations: (I) the same instructor taught two courses, one EBAE and one LB course, while homework and exams were the same, (II) the averages of student performances in both EBAE course and LB courses were compared where different courses were taught by different instructors. We found that, on average, students in EBAE courses outperformed those in LB courses on conceptual survey posttests even though there was no significant difference in the pretest. We also discuss the correlation between conceptual survey and the final exam scores which typically places a heavy weight on quantitative problem solving.

**DA03: 8:50-9:00 a.m. Characterizing Active Learning Environments in Physics: Preliminary Results***Contributed – Kelley Commeford, Drexel University, 7215 Emlen St., Philadelphia, PA 19119; kac473@drexel.edu**Eric Brewe, Drexel University**Adrienne Traxler, Wright State University*

There is broad evidence that active learning leads to improved student outcomes as compared with traditional lecture. Relatively little work has been done to distinguish outcomes from different types of active learning. We will be making COPUS observations and collecting network survey data from seven universities that exhibit active learning curricula. We will be using network analysis to characterize differences in student networks for each active learning environment. The COPUS data will be used to distinguish in-class activities. Together, these data will provide a baseline for identifying different forms of active learning. In this talk we provide a preliminary analysis of data from Peer-Instruction classes and classes using Tutorials in Introductory Physics.

**DA04: 9:00-9:10 a.m. Adapting Tutorials in Introductory Physics for New Populations and Environments***Contributed – Dean Carter Bretland, University of Washington, 12307 10th PI NE Unit D, Seattle, WA 98125-4822; deanbret@uw.edu**Sheh Lit Chang, Peter Shaffer, University of Washington*

The systematic development of effective teaching materials requires repeated use in classes with known constraints. While it can be tempting to implement materials with students and in environments different from those in which they were developed, the learning outcomes may be quite different. Tutorials in Introductory Physics were primarily designed for use in small groups sections associated with calculus-based physics courses, but currently, at the University of Washington they are being used in algebra-based courses in lectures of between 100 and 600 students. Through the use of online pre-tests and written exam questions, we are examining the extent to which the tutorials are effective in this new setting and trying to identify differences between the two populations that can guide the development of materials that better suit the needs of this new population. Examples from this research will be given to illustrate some of the findings.

**DA05: 9:10-9:20 a.m. Transforming Modeling Instruction in a Large Classroom Environment***Contributed – Idaykis Rodriguez, Florida International University, 11200 SW 8th street vh176, Miami, FL 33199; irodr020@fiu.edu**Geoff Potvin, Laird H. Kramer, Florida International University*

In the past four years, FIU has expanding its offering of modeling instruction (MI) for introductory physics from a 30-student classroom to one that accommodates up to 100 students using multiple teaching resources and implementing several structural changes. MI is a studio-based, active learning curriculum that is derived from social constructivist theories of learning. This expanded classroom has been found to consistently support student learning with strong conceptual learning gains across at least four different instructors. In this talk, we discuss the development of the larger classroom offering, including the strategic use of LAs, the coordination of multiple discussion circles, preparatory meetings with an instructional team spanning multiple sections, and detailed curricular modifications that supported the expansion of MI.

**DA06: 9:20-9:30 a.m. Deconstructing Mastery-Inspired Learning Activities***Contributed – Muxin Zhang, University of Illinois at Urbana-Champaign, 2057 S Orchard St, Apt B, Urbana, IL 61801-7639; mzhang17@illinois.edu**Tim Stelzer, University of Illinois at Urbana-Champaign*

Mastery-inspired online activities have been introduced into physics introductory courses at the University of Illinois. Clinical studies have shown that students perform much better on quizzes after completing mastery-inspired activities than traditional multiple attempts activities. To understand the importance of the various

components and their timing within the mastery-inspired activities —immediate feedback, multimedia help, and multiple versions of problems — we have created different variations of mastery-inspired activities and looked at how they affect students' quiz scores. This talk will share the results of our analysis.

**DA07: 9:30-9:40 a.m. Improving Student Understanding of Rolling Motion – Curriculum Development**

*Contributed – Sheh Lit Chang, University of Washington, 9027 Meridian Pl N, Seattle, WA 98103; shehlit@gmail.com*

*Peter S. Shaffer, University of Washington*

Prior research on student understanding of rolling motion has led to the identification of some specific difficulties that students have with this topic, including in the case of rolling without slipping. At the University of Washington, we have been building on this work and in the process of developing and testing a tutorial based on a relative motion approach to this topic. Results from pre-tests and post-tests will be given to illustrate some of the findings and to assess the utility of this approach.

**DA08: 9:40-9:50 a.m. Exploring Students' Understanding of the Motion of Rigid Body\***

*Contributed – Min-Fan Hsieh, National Changhua University of Education, 6F., No.25, Sec. 3, Hankou Rd., Taichung, Taiwan 404 Taiwan minfan.hsieh@gmail.com*

*Shih-Yin Lin, National Changhua University of Education*

One topic typically discussed in an introductory mechanics course is the motion of rigid body. However, our anecdotal experiences suggest that many students do not have a good understanding of the motion of rigid body, especially when rotation is involved. For example, few students know that any pair of particles on a rigid body doesn't have relative velocity toward or away from each other. In addition, students may not realize the constraints of choosing a reference point for torque and moment of inertia in the rotational equations of motion. In this study, a set of problems about the motion of rigid body and relevant rotational equations of motion is developed and administered to a group of students who have taken introductory mechanics course. Findings from the study will be presented.

\*Supported by the Ministry of Science and Technology, Taiwan under grant No. MOST 106-2511-S-018-003-MY2.

**DA09: 9:50-10:00 a.m. Teacher-Student Discourse in Active Learning Lectures**

*Contributed – Ross K. Galloway, University of Edinburgh, James Clerk Maxwell Building, Edinburgh, EH9 3FD United Kingdom ross.galloway@ed.ac.uk*

*Anna K. Wood, Christine Sinclair, Judy Hardy, University of Edinburgh*

Active learning lectures are becoming increasingly well studied, but an underexplored area is the nature of the dialogue between the instructor and the students during these sessions. We have conducted case studies of active lectures in a flipped-classroom introductory physics class, analysing them from a sociocultural perspective. From these, we have identified three main purposes for the dialogues: 1) Involving students in sense-making, 2) Guided expert modeling, and 3) Wonderment questions. We have also found that the structure of the dialogues is typically consistent with authoritative interactions (where the authority lies with the instructor), but that the learning environment of the flipped, active engagement class acts to create a learning context that can be described as ideologically dialogic. We will discuss how this combination of instructional design and the establishment of active classroom norms creates opportunities which may be beneficial for learning.

**DA10: 10:00-10:10 a.m. Using Students' Autobiographical Accounts to Inform Quantum Curriculum\***

*Contributed – Brandon James Johnson, University of Maryland, Toll Physics Building, Room 1322, College Park, MD 20742-2421; brandon.johnson110@gmail.com*

*Erin Ronayne Sohr, Ayush Gupta, University of Maryland*

Physics curriculum development has often privileged faculty perspectives. Instructors develop textbooks, lecture notes, and assignments; researchers probe student-subjects for their reasoning and difficulties, but students rarely participate in co-construction of curriculum (with some exceptions). To explore a contrasting approach that we hope can inform future curriculum development, we asked students to generate autobiographical video, audio, and written blogs and participate in open-format clinical interviews while taking an upper-division quantum mechanics (QM) course. We intended for students to have the freedom to generate their own critiques and appraisals of the class content and culture, including how it interacts with their broader experiences inside and outside of physics. Additionally, students own the blogging data, deciding what to share with researchers. We will present preliminary findings of these students' experiences. We will discuss insights about possible future QM curriculum development and course structure gleaned from these students' perspectives.

\* Support: NSF DUE #1625797

**DA11: 10:10-10:20 a.m. Evaluating JiTT and Peer Interaction Using Clickers in a QM Course**

*Contributed – Ryan T. Sayer, Bemidji State University, 1500 Birchmont Dr. NE, Bemidji, MN 56601-2699; rsayer@bemidjistate.edu*

*Emily Marshman, Chandralekha Singh, University of Pittsburgh*

Just-in-Time Teaching (JiTT) is an instructional strategy involving feedback from students on pre-lecture activities in order to design in-class activities to build on the continuing feedback from students. We investigate the effectiveness of a JiTT approach, which included in-class concept tests using clickers in an upper-division quantum mechanics (QM) course. We analyze student performance on pre-lecture reading quizzes and in-class clicker questions answered individually and then again after group discussion, and compare those performances with open-ended retention quizzes administered after all instructional activities on the same concepts. In general, compared to the reading quizzes, student performance improved when individual clicker questions were posed after lectures that focused on student difficulties found via electronic feedback. The performance on the clicker questions after group discussions following individual clicker question responses also improved, as did the performance on retention quizzes administered at a later time. We discuss some possible reasons for the improved performance at various stages, e.g., from pre-lecture reading quizzes to post-lecture clicker questions, and from individual to group clicker questions and retention quizzes. We thank the National Science Foundation for support.

**DA12: 10:20-10:30 a.m. The Force Concept Inventory (FCI) and English Learners**

*Contributed – Alfonso Reina, New York Institute of Technology, 9 Wenyuan Road, Nanjing, Jiangsu 210046 P.R. China; areina@nyit.edu*

Teaching and assessing English Learners (ELs) in the context of global campuses from American institutions face the challenge of adapting to the cultural background and language skills of students. Here, we describe insights from the implementation of the FCI in various versions (English, Simplified English, and native language) in populations of ELs from various countries, predominantly in China. The performance of students in the FCI is dependent on the form of the FCI given and the English skills of the students. We also use a Cochran-Mantel-Haenszel (CMH) test to identify biases in the different versions of the FCI when applied to ELs.

## Session DB: PER: Self-Efficacy, Motivation, Mindset and Epistemology

Location: Meeting Room 8/9

Sponsor: AAPT/PER

Time: 8:30–9:40 a.m.

Date: Tuesday, July 31

President: Cynthia Heiner

### DB01: 8:30-8:40 a.m. Investigating Physics Self-Belief of Secondary Students

Contributed – Cynthia Reynolds, *The College of New Jersey, 2000 Pennington Road, Ewing, NJ 08628; reynolc5@tcnj.edu*  
AJ Richards, *The College of New Jersey*

There exists a shortage of students who enter an undergraduate program of study or intend to pursue a career in physics. Even more critical in this shortage is the underrepresentation of women and minority groups. The reasons for this shortage are not yet known. We have chosen to investigate the impact of students' physics self-belief on their likelihood to pursue physics as a career. We designed and administered a survey instrument to secondary level physics and physical science students. The survey was designed to help educators understand how the levels of self-efficacy of middle and high school level students change as they progress through their educational careers in the subject of physics. The survey also investigated if a student's level of self-efficacy is directly related to how a student views a potential career in physics. In this presentation we will detail the trends we found between students' physics self-belief, demographics, and likelihood to choose physics as a career.

### DB02: 8:40-8:50 a.m. Research on Natural Science Transfer Students' First Year Experiences

Contributed – Angela J. Little, *Michigan State University, 567 Wilson Rd., East Lansing, MI 48824; angie.little@gmail.com*  
Sarah Maestrales, *Vashti Sawtelle, Michigan State University*

The College of Natural Science at Michigan State University recently received a National Science Foundation S-STEM Grant in partnership with Washtenaw Community College and Mott Community College (NSF#1742381). The grant focuses on scholarship money and holistic support for students during their time at Washtenaw and Mott as well as for students who transfer to Michigan State. The grant also includes a research program focused on transfer students' educational pathways. As part of this work, our team is interviewing current transfer students about their first year. These interviews are focused on students' experiences in math and science courses as well as with university structures and campus community more generally. In particular, we developed questions to probe two constructs key to students' experiences: self-efficacy and mindset. In this presentation, we give an overview of our study as well as preliminary findings from a set of student interviews.

### DB03: 8:50-9:00 a.m. Evolution of Students' Social Cognitive Attitudes and Beliefs in Physics

Contributed – Mike A. Lopez, *The Ohio State University, 1006 Physics Research Building, Columbus, OH 43210; mike8lopez6@gmail.com*  
Andrew F. Heckler, *The Ohio State University*

Social science researchers have that shown that social cognitive factors such as belonging, interest, and self-efficacy play an important role in retention and achievement in physics, especially among historically underrepresented populations (e.g. women and underrepresented minorities). However, there is a gap in the literature about how these factors evolve per semester enrolled in physics. We present descriptive statistics on over 1000 students enrolled in a physics course at The Ohio State University in the 2nd year of our tracked longitudinal and cross-sectional study. This work aims to characterize the evolution of students' social cognitive attitudes and beliefs in over 15 validated measures such as belonging, interest, self-efficacy, and mindset. In particular we focus on differences in the evolution of these factors by gender, ethnicity, academic year, physics vs non-physics major, and honors vs non-honors. We also report differences in outcomes including course grade, GPA, and retention among these populations.

### DB04: 9:00-9:10 a.m. The Impact of Prior Preparation and Motivational Characteristics on Learning Outcomes in Introductory Physics Courses

Contributed – Timothy J. Nokes-Malach, *University of Pittsburgh, 3939 O'Hara St., Pittsburgh, PA 15260-3583; nokes@pitt.edu*  
Zeynep Y. Kalender, *Emily Marshman, Chris Schunn, Chandralekha Singh, University of Pittsburgh*

Identifying factors that impact learning outcomes in physics courses is important for developing and implementing pedagogies and interventions to help students learn better. We have been collecting motivational data and performance outcomes on over 1000 students in introductory physics courses over the past several years. Here, we report on how prior preparation and motivational characteristics (such as self-efficacy) impact student performance in introductory physics courses. We also describe how prior preparation and aspects of motivational characteristics mediate effects of gender on learning outcomes. We thank the National Science Foundation for support.

### DB05: 9:10-9:20 a.m. Different Attitudes/Beliefs about Learning Physics Surveys Measure Different Things

Contributed – Andrew R. Elby, *University of Maryland, Dept. of Teaching & Learning, Policy & Leadership College Park, MD 20742; elby@umd.edu*

A variety of "attitudes and beliefs" surveys probe students' views about learning physics, including CLASS (Colorado Learning Attitudes about Science Survey) [1], MPEX and MPEX2 (Maryland Physics Expectations Survey) [2], VASS (Views About Science Survey) [3], and EBAPS (Epistemological Beliefs Assessment for Physical Science) [4]. Each of these surveys, however, probes a slightly different aspect of students' views. In this talk, I tease apart those differences. These distinctions can help researchers select the survey best suited for their particular research questions.

1. W. K. Adams, K. K. Perkins, N. S. Podolefsky, M. Dubson, N. D. Finkelstein, & C. E. Wieman, "New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey," *Phys. Rev. Spec. Topics - PER*, 2(1), 010101 (2006). 2. E. F. Redish, J. M. Saul, & R. N. Steinberg, "Student expectations in introductory physics," *Am. J. Phys.*, 66(3), 212-224 (1998). 3. I. Halloun, & D. Hestenes, "Interpreting VASS dimensions and profiles for physics students," *Science & Education*, 7(6), 553-577 (1998). 4. A. Elby: <http://www2.physics.umd.edu/~elby/EBAPS/home.htm>

### DB06: 9:20-9:30 a.m. Small Group Discourses and Epistemic Agency in Introductory Physics Course

Contributed – Mark Akubo, *Florida State University, 114 W. Call St., Tallahassee, FL 32306-4450; ma15d@my.fsu.edu*  
Claussell Mathis, *Cody Smith, Sherry Southerland, Florida State University*

Research findings in physics education suggest that if students are supported to be more actively engaged in knowledge-construction, they demonstrate greater learning gains and develop deeper conceptual understanding. In this qualitative case study, we explore how students' interactions in small groups might influence their epistemic agency in an introductory physics course within a student-centered active learning environment for undergraduate programs (SCALE-UP). We focus on two small groups and examine observation data gathered using the classroom observation protocol for epistemic agency (COPEA) and video data. Preliminary findings suggest that the nature of small group discourses influences the level of epistemic agency that students exercise. Epistemic agency reminds us that students are

not passive recipients of knowledge as mere information, transmitted from the teacher as the only authority on knowledge in the classroom. Rather, students have the capacity to take responsibility to construct knowledge more actively in the classroom community.

**DB07: 9:30-9:40 a.m. “Representational Blending”: Students’ Attempts at Reconciliation Across Representations of Waves\***

*Contributed – Hannah Christine Sabo, The University of Maryland, 3942 Campus Dr., College Park, MD 20742; hsabo13@gmail.com*

The UMD PhET Project seeks to develop, test, and iteratively refine tutorials that pair with PhET Simulations, aimed at introductory physics students. Testing included video recording of small groups of students using the tutorials. Fauconnier and Turner (2003)\*\* introduce conceptual blending, where students construct a partial match between two mental spaces. The Waves tutorial focused on reconciliation across four different representations of waves. In this presentation, I will discuss how two students talked interchangeably about (i) their “real world” perception of ripples and (ii) features of one representation in the simulation, without drawing explicit distinctions between the two, thus carrying out “representational blending.” I will discuss whether this blending of representations is conceptual blending. I will then examine the affordances and constraints of “representational blending” in physics curriculum.

\*Work supported by NSF Grant 1245400. \*\*Fauconnier, G., & Turner, M. (2003). Conceptual blending, form and meaning. *Recherches En Communication*, 19(19), 57–86.

**Session DC: Best Practices in Educational Technology**

**Location:** Mount Vernon Square B **Sponsor:** Committee on Educational Technologies **Time:** 8:30–10 a.m. **Date:** Tuesday, July 31 **President:** Bruce Mason

**DC01: 8:30-9:00 a.m. Using Mobile Devices as Data Sensors for Laboratory Experiences**

*Invited – Vieyra Software, Vieyra Software, 225 C St. SE, Washington, DC 20003; chrys.vieyra@gmail.com*

*Chrystian Vieyra, Vieyra Software*

*Benjamin Xu, University of Texas at Austin*

*Diana Price Alexandria Public Library*

Mobile devices are becoming ubiquitous among students, teachers, other STEM professionals, and the general population as useful measurement tools. Importantly, the same tools used by secondary students are proving to be useful in high-level engineering and scientific research. Panelists who have collaborated on the development of these tools will include a prior high school physics educator, a software engineer, and an undergraduate computer science student. These panelists will share anecdotes of their interactions with the STEM-curious with mobile sensors, from outreach with elementary children through collaborations with experienced professionals. They will share their expectations for the future of mobile sensor development and will be eager to receive feedback from the audience about their own desires for mobile technology in physics education.

**DC02: 9:00-9:30 a.m. Perusall: A Social learning Platform to Encourage Active Reading**

*Invited – Brian Lukoff, Perusall LLC, PO Box 40131, Austin, TX 78704; brian@perusall.com*

*Kelly Miller, Harvard University & Perusall LLC*

We illustrate the successful implementation of pre-class reading assignments through Perusall, a social learning platform that allows students to discuss the reading online with their classmates. Perusall encourages students to come to class prepared by facilitating social interactions around the course content and by automatically grading students’ work. We show how the platform can be used to understand how students are reading before class. We identify specific reading behaviors that are predictive of in-class exam performance. We also demonstrate ways that the platform promotes active reading strategies and produces high-quality learning interactions between students outside class. Finally, we compare the exam performance of two cohorts of students, where the only difference between them is the use of the platform; we show that students do significantly better on exams when using the platform.

**DC03: 9:30-10:00 a.m. Performing Real Science in a Virtual Environment with Video-based Experiments**

*Invited – Matthew Vonk, University of Wisconsin River Falls, 410 S 3rd St., River Falls, WI 54022; matthew.vonk@uwrf.edu*

*Peter Bohacek, Pivot Interactives SBC*

In this session, we’ll explore some of the ways that technology can facilitate the learning of science concepts as well as acquisition of scientific abilities. In particular, we’ll look at new video-based experiments (Pivot Interactives) that allow students to practice many science skills including: • closely observing an interesting phenomenon • asking questions about that phenomenon • designing experiments to answer those questions • collecting meaningful data • analyzing that data (often with graphs) • drawing conclusions • representing those conclusions in graphical, verbal, and algebraic form • using the results to make predictions about new phenomena Obviously the acquisition of these skills does not \*require\* advanced technology, each can be done (and has been) using the most basic tools. Yet, technology is especially good at reducing the cognitive load associated with each of these tasks. By reducing the unproductive struggle associated experiment logistics students can fully engage in the productive struggle associated with an authentic scientific approach.

**Session DD: Exploring Physics Apps and Learning to Use Them**

**Location:** Congressional Ballroom A **Sponsor:** Committee on Educational Technologies **Co-Sponsor:** Committee on Teacher Preparation **Time:** 8:30–10 a.m.

**Date:** Tuesday, July 31 **President:** Nina Morley Daye

*(This session will run as a series of stations set up in a room that the participants will move through.)*

**DD01: 8:30-10:00 a.m. Measuring Vertical Velocities of Elevators Using Smartphone Pressure Sensors**

*Contributed – Arturo C. Marti, UdelaR, Montevideo, Uruguay Igua 4225 Montevideo, Montevideo 11400 Uruguay marti@fisica.edu.uy*

*Marti Monteiro, ORT University*

We propose an experiment to measure the vertical velocities of elevators, pedestrians climbing stairs, and UAV by means of smartphone pressure sensors. Using an approximation valid in the first hundred meters of the atmosphere, the altitude and vertical velocities are obtained. After performing a numerical integration, we compare our results with those obtained with the built-in accelerometer. We show that data obtained using the pressure sensor is significantly less noisy than that

obtained using the accelerometer. Error accumulation is also evident in the numerical integration of the acceleration values. The pressure sensor also outperforms GPS which does not receive satellite signals indoors and the operating frequency is considerably lower than that of the pressure sensor. Comparison with reference values taken from the architectural plans validates the results obtained using the pressure sensor. This proposal is ideally performed as an external or outreach activity with students. Phys. Educ. 52 (2017) 015010

**DD02: 8:30-10:00 a.m. Webassign Beyond Traditional Chapter Problems**

*Contributed – Richard A. Zajac, Kansas State Polytechnic, 2310 Centennial Road, Salina, KS 67401-8196; rzajac@ksu.edu*

The strength of Webassign remains the flexibility it provides for instructors to write/rewrite problem scripts to suit the eccentricities of their individual classrooms and teaching styles more usefully than do the stock problems provided as instructional resources with standard texts. Continued efforts are presented whereby homework is written/customized to match individual teaching style, specifics of local student lab experiences, and useful pop-cultural references. More significantly, evolving experience naturally leads the instructor to explore extending the uses of online homework in directions that abandon the limitations imposed by trying to mimic traditional textbook problems.

**DD03: 8:30-10:00 a.m. Classroom Response Made Easy with the PLICKERS App**

*Contributed Joshua B. Winter, BASIS Independent Brooklyn, 556 Columbia St., Brooklyn, NY 11231; joshua.winter@basisindependent.com*

We all appreciate the value of formative assessments and know how valuable immediate feedback from our students is. But paper and pencil quizzes are time consuming and many of the classroom response systems used to obtain this information quickly are clunky or prohibitively expensive. It the PLICKERS app to the rescue! All you need is your smart phone (students don't need one). There are no expensive clickers for students to buy (and possibly lose). Learn how this FREE, easy to use, classroom response app can be implemented in your physics classes now.

**DD04: 8:30-10:00 a.m. Authentic Learning Opportunities with the Aurorasaurus.org Citizen Science Platform**

*Contributed – Elizabeth A. MacDonald, \* NASA Goddard Space Flight Center, 8800 Greenbelt Rd., Greenbelt, MD 20771; e.a.macdonald@nasa.gov*

Aurorasaurus is the first citizen science project about the beautiful aurora. Auroras are the end result of a cascade of plasma physics beginning on the Sun and ending with visible lights in near Earth space. Citizen scientists can increase their chances to see aurora, contribute to helping others see aurora, help scientists improve very coarse models of aurora, and actively learn more about space physics in the process. Recently, citizen scientists have even captured features of aurora-like arcs not previously described in the literature at subauroral latitudes and contributed to ground-breaking new publications and understanding. Participants will learn how to use the app from the project's founder, space physicist Dr. Elizabeth MacDonald of NASA's Goddard Space Flight Center.

\*Sponsored by Rebecca Vieyra

**Session DE: History of Historically Black Colleges and Universities**

**Location:** Marriott Marquis - Chinatown Room **Sponsor:** Committee on Diversity in Physics **Co-Sponsor:** Committee on Research in Physics Education

**Time:** 8:30–10 a.m. **Date:** Tuesday, July 31 **President:** Juan Burciaga

**DE01: 8:30-9:00 a.m. Physics Research, Teaching, and Student Training at Fisk University: 1895 -1970**

*Invited – Ronald A. Mickens, Clark Atlanta University, 223 Brawley Drive at Fair St., Atlanta, GA 30314; rmick23756@aol.com*

We summarize the history of science education at Fisk University. The period covered begins at the end of the 19th century and ends in 1970. In particular, we discuss reasons for the heavy emphasis on science and mathematics in the university's curriculum and the subsequent consequences for the teaching of physics, physics student education and training, and both faculty and student research activities. A major figure, specially during the 1930's, was Elmer Samuel Imes, who graduated from Fisk in 1903, and then obtained the doctorate degree in physics in 1918 from the University of Michigan. We conclude the presentation with details regarding the Fisk – Vanderbilt Bridge Program and some comments on current STEM efforts for increasing minority participation in physics.

**DE02: 9:00-9:30 a.m. Curricular Reform and Physics Education Research at Spelman College**

*Invited – Derrick Hylton, Spelman College, 350 Spelman Lane, Box 294, Atlanta, GA 30314; dhylton@spelman.edu*

Based on student learning outcomes, the Physics Department at Spelman College has initiated several curricular reform over the past 10 years. These are based on physics education research. In addition, we have started some education projects on our own. We will describe our efforts on curricular reform and our physics education research projects over the past 10 years and continuing. We will also present our successes and weaknesses, as well as lessons learned that may benefit other institutions thinking about such projects.

**DE03: 9:30-10:00 a.m. Overview of Physics at Historically Black Colleges and Universities**

*Invited – Gregory Good, American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3843; ggood@aip.org*

This presentation provides an overview of what is known now about the history of physics teaching at HBCUs. It also provides some guidance for finding the existing literature on this topic. More importantly, this talk provides advice on topics—schools, individuals, inspirational stories -- that might allow physics students and teachers to fill gaps in that history. Lastly, all of this draws on the Teaching Guides on Women and Minorities in Physics on the American Institute of Physics website at <https://www.aip.org/history-programs/physics-history/teaching-guides-women-minorities>

## Session DF: Introductory Labs/Apparatus II

Location: Marriott Marquis - Magnolia

Sponsor: AAPT

Time: 8:30–10:10 a.m.

Date: Tuesday, July 31

President: Sam Sampere

### DF01: 8:30-8:40 a.m. Designing and Facilitating Experimental Design Tasks to Support Collaboration

Contributed – Gabriel S. Ehrlich, University of Illinois at Urbana-Champaign, 1110 W Green St., Urbana, IL 61801; gse2@illinois.edu  
Mats A. Selen, University of Illinois at Urbana-Champaign

Collaborative tasks are difficult to design but worthwhile: students working collaboratively on problem-solving tasks construct abstractions significantly more often than the single strongest student in the group would alone (see footnote). Students seem to collaborate better on open-ended tasks, so a classroom setting in which students design their own experiments is plausibly conducive to collaboration. Indeed, we observed spontaneous collaborative problem-solving emerge in an introductory laboratory course based on experimental design. Using video data of group work, we investigated the roles that the teacher and the task played in supporting collaboration. Our presentation will identify characteristics of tasks and facilitation that motivate students to collaborate on the construction of knowledge.

Schwartz, D. L. (2009). "The Emergence of Abstract Representations in Dyad Problem Solving." *Journal of the Learning Sciences*, 4 (#3) 321-354 (34 pages). DOI: 10.1207/s15327809jls0403\_3.

### DF02: 8:40-8:50 a.m. Disproving (and Re-proving) the Ideal Gas Law

Contributed – Dean A. Stocker, University of Cincinnati Blue Ash College, 9555 Plainfield Rd., Blue Ash, OH 45236; dean.stocker@uc.edu  
Tonnetta C. Elliott, Socheaththa K. Phouny, University of Cincinnati Blue Ash College

Our algebra-based general physics lab at UC Blue Ash uses a PASCO Heat Engine / Gas Law Apparatus to demonstrate that volume is proportional to temperature for an ideal gas when pressure and the number of molecules are both held constant. However, carefully collected data does not show a linear relationship between temperature and volume. An apparent contradiction of the ideal gas law! This provides an interesting challenge for the students, and it is a challenge whose solution cannot be easily found on the internet. A careful inspection of the equipment and proper application of the ideal gas law actually does predict a curve for this instrument when measuring volume as a function of temperature. The math required for determining the shape of the curve when the temperature is increasing is beyond the scope of algebra-based physics, but the curve when the temperature is decreasing has an algebraic solution.

### DF03: 8:50-9:00 a.m. Measuring Magnetization of a Magnet\*

Contributed – Biplob Barman, University of Michigan-Flint, 303 E. Kearsley Street, 207 Murchie Science Bld., Flint, MI 48502; United States bbarman@umflint.edu  
Athos Petrou, University at Buffalo, The State University of New York

The effect of an external magnetic field  $B$  on magnetic materials is a subject of immense importance. The simplest and oldest manifestation of such an effect is the behavior of the magnetic compass. Magnetization  $M$  plays a key role in studying the response of magnetic materials to  $B$ . In this talk, an experimental technique for the determination of  $M$  of a permanent magnet will be presented. The proposed method discusses the effect of  $B$  (produced by a pair of Helmholtz coils) on a permanent magnet, suspended by a string and allowed to oscillate under the influence of the torque the magnetic field exerts on the magnet. The arrangement uses mechanical energy conservation principles to measure  $M$  via graphical analysis. This low cost experiment is suitable for both AP physics students as well as an advanced lab for undergraduate Physics and Engineering majors.

\*This work was supported by NSF DMR-1305770.

### DF04: 9:00-9:10 a.m. Inductional Levitation of Electromagnetic Wheels

Contributed – Angel Gutarra-leon, Northern Virginia Community College, 10594 Reeds Landing Cir., Burke, VA 22015; agutarr2@masonlive.gmu.edu  
Walerian Majewski, Northern Virginia Community College

We constructed two circular neodymium magnet array wheels in both Halbach and non-Halbach arrangements with strong alternating pole magnetic fields on the outer rims of the wheels. Such systems are referred to as electrodynamic wheels (EDW). A Halbach array is a series of magnets which have their magnetic dipole directions rotated by 90 degrees at each adjacent position. Our non-Halbach array created somewhat weaker alternating fields around the rim with magnetic dipole moments arranged circumferentially with reversing polarity. Our experiments measured the lift and drag forces produced by these spinning wheels on conducting plates which play a role of the tracks, at varying rotation speeds of the wheels. These forces were compared with theoretical predictions for the ratio of lift to drag. We found that the lift to drag ratios for both wheels followed the predicted linear relationship as functions of angular velocity of the rotating magnetic field.

### DF05: 9:10-9:20 a.m. Robotics in Physics Lab

Contributed – Ravin Kodikara, Webster University, 470 East Lockwood Ave, St Louis, MO 63119; ravinkodikara30@webster.edu

A series of simple robotics and automation activities were designed and tested to be used in conventional introductory physics laboratories. The first of the series introduces microcontroller programming and basics of electronics using widely available Arduino Uno module. During the second lab activity students will investigate programming a mobile robot to simulate a given physical scenario. Typically this includes moving the robot at certain speeds, maintaining certain accelerations for given time periods and covering set distances. Students were later challenged to simulate circular, elliptical, and parabolic paths while maintaining certain speeds. At a secondary stage, a multi axis robot arm was used to introduce spherical and cylindrical coordinate systems. Pre-lab and post-lab assessments were conducted and comparisons were made against conventional lab results.

### DF06: 9:20-9:30 a.m. Materials Characterization of Nanocellulose in the THz Regime

Contributed – Jing Gao, Kean University, Chemistry / Physics 1000 Morris Ave., Union, NJ 07083; berhall@kean.edu  
Beranrd Hall, Frank D'Agusto, Daniel Rosenfeld, Kean University

Nanocellulose is a relatively new material with a wide range of possible applications. One potential application is use in the manufacture of semiconductors. The properties of this material, including index of refraction, absorption coefficient and dielectric constant in the THz regime are important factors when considering the applicability of this material to the semiconductor industry. In this paper we present results for these properties for both ordinary paper and nanocellulose utilizing a time domain terahertz spectrometer. The Physics / Chemistry theory and experimental procedure used in this paper are easily accessible to undergraduate students in Physics and Chemistry making this an excellent opportunity for undergraduate students to learn the skills needed to practice real world science.

**DF07: 9:30-9:40 a.m. The Fitbit and Faraday: A Physics Adventure Towards Mechanical Lighting**

Contributed – Stephen J. Mecca, Providence College, 1 Cunningham Square, Providence, RI 02908; smecca@providence.edu

Liam J. Reilly, Providence College

The value of lighting for an off-grid village household is undeniable. Yet, the realities of poverty and the unavailability of affordable local options often preclude even simple solar and other battery powered devices. The S-Lab has explored mechanical lighting options with the hope of having a locally made option. The project began with simple functional analyses leading to spring- shake- gravity- type systems and then the possibility of using the fitbit, a low friction spinner that can persist for several minutes. The fitbit, which may be a detour from our original design problem, has proven to be an interesting physics adventure in its own right, allowing the possibility of generating sufficient voltage to light LEDs. This paper will present: questions that arise in developing a magnetic flux change to effect a sizeable EMF to be rectified and used for simple lighting, a model representing the process, and some preliminary results.

**DF08: 9:40-9:50 a.m. Undergraduate Computational Research Opportunities in Introductory Courses**

Contributed – Michael Butros, Victor Valley College, 18422 Bear Valley Road, Victorville, CA 92395; Michael.Butros@vvc.edu

Funded by an NSF-CREST grant students in Introductory Physics courses at Victor Valley College (VVC) have the opportunity to participate in undergraduate computational research projects during the winter break. This presentation will discuss the “Winternship” program at VVC, observations and outcomes, and future plans.

**DF09: 9:50-10:00 a.m. Methodological Aspects Related to the Students’ Performance of Laboratory Work**

Contributed – Genrikh Golin, Touro College, 448 Neptune Ave. # 15K, Brooklyn, NY 11224; Genrikhgolin@yahoo.com

When performing experiments independently in a HS physics laboratory, the students can acquire several practical and intellectual skills that are needed for future work in industry or research. But this can be achieved only under certain conditions. In doing an experiment, each student should behave as a real researcher. Thus each student should not simply perform some prescribed procedures but should independently design and carry out an experiment. In this way the student will experience all the joys and pain inherent in creative work, and feel the connection between theory and experiment. It is also important to learn how to report and systematize observational results and to formulate conclusions. The laboratory work report must be concise and convey the main observations, measurements, experimental set-up, formulae, calculations, tables, diagrams, final conclusions. It is desirable to teach the students to generalize and predict future experimental results, and to formulate conclusions on reliability of the data that were obtained. During the talk I will show some strategies and examples of carrying out the experimental work.

**DF10: 10:00-10:10 a.m. An Everyday Life-based Route to Learning about Nano-technologies in High Schools**

Contributed – Peppino Sapia, University of Calabria - Department of Biology, Ecology and Earth Sciences, Ponte Bucci, Cubo 4B, Rende, 87036 Italy peppino.sapia@unical.it

Assunta Bonanno, University of Calabria - Department of Biology, Ecology and Earth Sciences

Giacomo Bozzo, University of Verona - Department of Computer Science

Andrea Checchetti, High School I.I.S. “Leonardo Da Vinci”

The Nanoworld attracts ever-increasing attention, especially because of its technological applications at the molecular and atomic scale, and the prefix “nano” is ubiquitous in popular science and mass media. From a pedagogical perspective, the Nanoworld offers a mess of possibilities for implementing truly interdisciplinary learning paths involving physics, chemistry, and life sciences. In this context, we have designed a hands-on learning sequence on nanotechnologies, suitable for high school students, inspired to the PBL (Project-Based-Learning) paradigm. The learning sequence was proposed to a group of students attending as apprentices in the Laboratory of Applied Physics for Cultural Heritage at the University of Calabria, within an Italian national project aiming to promote high school students’ skills in a real working context. The practical goal of the PBL activity was to develop a “toy” superhydrophobic film, similar to those used as protective coatings for monuments and artworks. In accomplishing this task, students got in touch with many of the concepts pertaining to the science and technology of the Nanoworld.

**Session DG: Panel – Physics Identity in Informal Programs**

**Location:** Marriott Marquis - Silver Linden **Sponsor:** Committee on Research in Physics Education **Co-Sponsor:** Committee on Science Education for the Public

**Time:** 8:30–10 a.m. **Date:** Tuesday, July 31 **Presenter:** Katie Hinko

*Informal activities offer opportunities for teachers and learners that formal learning environments do not offer and are often designed with the explicit goal of building physics/ science identity in its participants. There are a growing number of researchers in the PER community whose focus is on identity; however, identity is most often discussed from the perspective of formal learning environments. Additionally, facilitators of informal learning settings may be looking for tools to study identity (and its intersection with other constructs like interest and content learning) in their programs. In this panel we will explore research-based ideas on the design of informal environments to promote physics identity and the use of identity frameworks to study informal learning settings. This dynamic panel session brings together researchers and practitioners. Speakers will each give a 15-minute presentation, which will be designed to engage the public and will have significant time for questions. After all speakers’ introductory presentations there will be an interactive panel discussion about the different ideas presented, with questions taken from the audience as well as prepared in advance by the moderator. The panelists for this session are Claudia Fracchiolla (University of Colorado and University College Dublin), Shane Bergin (University College Dublin), and Zahra Hazari (Florida International University). Katie Hinko (Michigan State University) will moderate. These panelists bring different perspectives, comprising both researchers and practitioners as well as U.S. and international speakers, who will collectively broach topics including: understanding the impact of participation in informal physics programs on identity at different levels from graduate students to undergraduates to youth; differences and connections between informal and formal settings; and the diversity of types of informal programs such as school settings or public-facing campaigns.*



## Session DH: PIRA: "Demos Changed My Life!"

Location: Marriott Marquis - Dogwood

Sponsor: Committee on Apparatus

Time: 8:30–10:10 a.m.

Date: Tuesday, July 31

President: Paul Nord

### DH01: 8:30-9:00 a.m. Demonstrations of Science as Entertainment

*Invited – Tom Noddy,\* 2120 N Pacific Ave #93, Santa Cruz, CA 95060; thebubbleguy@aol.com*

I am not a teacher nor an academic. I'm a professional entertainer. My performances feature the remarkable things that I've taught myself to do with soap bubbles. I've been featured on national television shows throughout the world. In the 1980s I worked with Frank Oppenheimer at the Exploratorium, San Francisco's science center, to create the first ever Bubble Festival, for a weekend that drew 15,000 to the museum. I will share my "act" as presented at museums and schools. Even those with knowledge of this field find surprises in the presentation and physics involved. I will speak of a good friend and collaborator, Eiffel Plasterer, an Indiana high school teacher, who used soap bubbles in his classroom. He was an educator who became an entertainer. His work and mine are similar and different. Eiffel is gone now but I will surprise some with reports of his work and his words.

\*Visit made possible with support of PIRA and the AAPT.

### DH02: 9:00-9:30 a.m. Magician - Musician - Student - Communicator - Facilitator

*Invited – Roger Key, Physics Department, California State University, Fresno, 2345 E San Ramon Ave MS MH37, Fresno, CA 93740; rogerk@csufresno.edu*

"Demonstrations are for the student and not the instructor," is a wise statement from a book by Richard M. Sutton published in 1938. I am grateful for teachers in my past who understood this well. Many of us work behind the scenes, supporting what goes on in front of an audience – a noble role with seemingly little influence. I present my own history of being influenced -- and perhaps providing gentle guidance to others -- whenever aspects of science, specifically demonstrations of physics, are performed for an audience.

### DH03: 9:30-9:40 a.m. The Best Physics Demos You're NOT Doing

*Contributed – James Lincoln, PhysicsVideos.com, 43 Hartford, Newport Beach, CA 92660; lincolnphysics@gmail.com*

In this talk I will perform as many demonstrations as I can reasonably fit into my timeslot! Most of these are either original or rarely seen. A focus is put on demonstrations that everyone can do without buying any new equipment. That is, you probably already own these apparatus, but you are just not doing it yet. Another focus is that they are awesome demos that you will want to perform for your students. Many have appeared in youtube.com/AAPTfilms but some have NEVER BEEN SEEN BEFORE!!!

### DH04: 9:40-9:50 a.m. The Dessert Creates Space for the Meal

*Contributed – John Barr, Lindenwood University, 209 South Kingshighway, St. Charles, MO 63301; jbarr@lindenwood.edu*

*Sajalendu Dey, Lindenwood University*

Every curriculum has a checklist that should allow students to achieve mastery of a series of concepts and problems. This is difficult for most introductory physics students, and it can be tempting to sacrifice thought experiments and demonstrations in order to spend more time on the tangible. However, the contextualized concepts unveiled in demonstrations often pay dividends in student motivation. Necessary but mundane activities become more palatable when the "why" is supplied, and there is a chance of kindling a joy in understanding that is irreplaceable. Examples include explanations of the direction of beach breezes, pulling a truck from a ditch, producing beats in the classroom, and the colorful rotation of polarization by corn syrup. Students have been brought to tears for the sheer beauty and marvelous nature of the universe. Forgoing the opportunity to inspire such wonder in the service of curriculum or proficiency seems a poor bargain.

### DH05: 9:50-10:00 a.m. Taking Demonstrations for a Spin

*Contributed – David E. Sturm, Department of Physics & Astronomy, University of Maine, 5709 Bennett, Orono, ME 04469-5709; sturmd@maine.edu*

Somewhere in a small electric motor manufacturing plant was a defining moment when a physics demonstration first captivated me. Often, the reasons we choose to do demonstrations in teaching physics is not because of an experience in a physics classroom, but experiences in our childhood. How do we understand demonstrations before we have the necessary physics? And how does this inform how we demonstrate to the public without using these "necessary" words?

### DH06: 10:00-10:10 a.m. Projectile Motion Sprinkler

*Contributed – Paul Fratiello, Eckerd College, 4200 54th Ave. S., St. Petersburg, FL 33711; fratiepj@eckerd.edu*

As a high school physics teacher I came across a photograph in a text book showing streams of water from a hose to demonstrate the path of projectiles fired at a variety of angles. The photograph looks like an overlay of four pictures and included no information about the angle of the streams. Several years ago I created what I call the "Projectile Motion Sprinkler" that allows the simultaneous projecting of water streams at angles of 20,30,45,60, and 70 degrees so the students can see the relationship between the angle and the projectile path. I believe every sprinkler should be a part of everybody's collection of demonstration equipment. Along with the description, I will discuss how to make one, and how it can be incorporated into your lesson.

## Session DI: Star Trek Physics

**Location:** Marriott Marquis - Cherry Blossom **Sponsor:** Committee on Modern Physics **Co-Sponsor:** Committee on Physics in High Schools **Time:** 8:30–10 a.m.  
**Date:** Tuesday, July 31 **President:** Martin Shaffer

### DI01: 8:30-9:00 a.m. Captain, Long Range Sensors Detect Intelligent Lifeforms

*Invited – Helio Takai, Brookhaven National Laboratory, Physics Department, Building 510A, Upton, NY 11973; helio.takai@gmail.com*

The USS Enterprise, NCC 1701 (and successors) is equipped with a range of sensors that is a dream of many physicists. Every show of the original or subsequent series displayed a sensor array that can scan entire stars, detect lifeforms, and many other tasks. All sensors are connected to the ship's artificial intelligence computer that can interpret the data making recommendations. How far are we from this type of sensors, and what kind of physics we need to understand to make them a reality? There are reasons to be optimistic. Many of the concepts introduced by Star Trek are becoming real, some more visible than others. A self-driving car is one example where sensors feed an artificial intelligence engine to find its way in traffic. Others are not so visible. High-energy physics experiments have been developing sensors to detect various types of particles that one day could be used to scan extensive sources of radiation. All sensors use fundamental material properties and their response to transform the interaction of a particle or field to electric signals. In this presentation, we will discuss the physics behind sensors, their evolution and how far we are from having the same capabilities of the USS Enterprise. Of course, physics is behind all sensors. Oh, my!

### DI02: 9:00-9:30 a.m. Science Fiction Made into Science Reality

*Invited – Gabriel C. Spalding, Illinois Wesleyan University, 201 E. Beecher St., Bloomington, IL 61702; gspalding@iwu.edu*

We've now made holograms that don't just look three-dimensional, they actually cause nearby nano-components to self-assemble into place, providing real three-dimensional substance to the structures. Following Star Trek, we call this "The Holodeck." We'll explain the difference between these effects and those involved in the functional "Tractor Beams" that we've also made. In addition, we've created functional "Sonic Screwdrivers," and if you're going to make a sonic screwdriver, any Doctor Who fan will tell you that you'll naturally want to control time. So motivated, we have even experimentally produced a movie of something that, in a basic sense, is traveling backwards in time, and gone further, demonstrating time reversal of encoded, transmitted information. To this odd mix, we've now added to our experimental toolkit a "Quantum Replicator," which — as you might guess — is where things start to get a bit weird. Don't worry, no laws have been broken, but prepare for your mind to be blown: come enjoy a string of videos illustrating how we've turned some of the fantasies of science fiction into experimental realities.

### DI03: 9:30-9:40 a.m. Teaching Science of Star Trek with Connections to Philosophy

*Contributed – Brock Russell, Riverside City College, 4800 Magnolia Ave., Riverside, CA 92507; brock.russell@rcc.edu*

Star Trek provides an excellent entry point for students to learn about physics, and it offers an interesting way to connect science with philosophical ideas and historical concepts. In this talk, I will discuss the design and teaching of a science and philosophy of Star Trek course, which was geared toward the general student population, including science and non-science students. This class included conceptual explanations of a large range of physics topics, from Newtonian mechanics to quantum mechanics and relativity. Through the lens of Star Trek, these science concepts were connected to large philosophical ideas, including the definition of life, and historical issues, such as the ethical dilemmas involved when interacting with civilizations of different technological development. This resulted in many interesting class discussions.

### DI04: 9:40-9:50 a.m. Using "The Physics of Star Trek" to Teach Modern Physics Concepts

*Contributed – Frank D. Lock, Georgia State University, physTEC, c/o 4424 Sardis Rd., Gainesville, GA 30506; flock@gsu.edu*

In 1995, "The Physics of Star Trek" was written by Lawrence Krauss. The second edition of the book was published in 2007. In 1997 the book was used for the first time in my classes to introduce the high school physics students to modern physics topics. These include time travel, the theory of relativity, the Michelson, Morely experiment, the expansion of space, spacetime, the conversion of mass into energy, quarks, antimatter, and more. Strategies that can be used in a high school physics class and introductory college courses to introduce modern physics topics to students will be presented.

### DI05: 9:50-10:00 a.m. From Einstein to Star Trek – Developing an On-line Summer Course

*Contributed – Steven C. Sahyun, University of Wisconsin - Whitewater, 800 W Main St., Whitewater, WI 53190-1319; sahyuns@uwv.edu*

This talk will describe experiences in transitioning a course entitled "From Einstein to Star Trek" from a face-to-face fall/spring semester course to a fully online summer term course. This course surveys modern physics starting with Einstein's relativity theories and biography and progresses to discuss some of the physics principles seen in science fiction films. Course structure and pedagogy will be discussed as well as techniques used to capture student interest.

## Session DJ: Panel – The Model Minority Myth and Disaggregation of Asian Student Data

**Location:** Marriott Marquis - Tulip **Sponsor:** Committee on Research in Physics Education **Co-Sponsor:** Committee on Diversity in Physics  
**Time:** 8:30–10:30 a.m. **Date:** Tuesday, July 31 **President:** David Marasco

### DJ01: 8:30-10:30 a.m. APIA History and the Creation of the Model Minority Myth

*Panel – Janelle S. Wong, \* Department of American Studies, University of Maryland, 2335 Tawes Hall 7751 Alumni Drive, College Park, MD 20742; janellew@umd.edu*

Janelle Wong will discuss evolving stereotypes faced by Asian Pacific Islander Americans (APIAs) and how they are rooted in history and U.S. immigration policies. The model minority myth consists of commonly held stereotypes regarding APIAs. Stereotypes include (but are not limited to) the depiction of APIA-origin students as excessively studious, collectivist, hardworking, shaped by Confucian and strong family values, and naturally excelling at math and science. These stereotypes serve to minimize pressing issues such as language barriers and poverty and can negatively impact mental health and sense of political agency. In addition, the model minority myth serves to undermine calls for racial justice when used to discredit and dismiss claims of racial discrimination. Finally, the model minority myth emphasizes individual responsibility and cultural values, while ignoring structural influences, such as immigration policies that prioritize the selective recruitment of highly educated and skilled professionals.

\*Sponsored by David Marasco

**DJ02: 8:30-10:30 a.m. Disaggregation of Student Data to Understand the Diverse APIAA Population**

Panel – *Quyen T. Dinh, \* Southeast Asia Resource Action Center (SEARAC), 1628 16th St. NW, Washington, DC 20009; quyen@searac.org*

Data disaggregation refers to the breakdown of aggregate data into smaller, measurable units of data. Quyen Dinh will discuss how the collection and analysis of detailed data on different Asian Pacific Islander American (APIA) national-origin groups serves to highlight educational disparities that remain invisible without such data. For example, while almost 50 percent of all APIAs have obtained a college degree, for some APIA groups, such as Burmese, Vietnamese, Cambodian, and Hmong Americans, rates of college-completion are lower than 20 percent. The collection and analysis of high-quality, disaggregated data on APIAs is important for informing evidence-based policy around the distinct needs of these diverse communities and identifying unique barriers to access of services and support. Using disaggregated data not only helps policymakers to develop substantive quantitative stories about inequality within the APIA community, it is also critical to helping educators to better understand their students' diverse educational experiences.

\*Sponsored by David Marasco

**DJ03: 8:30-10:30 a.m. Addressing APIA Stereotypes and Academic Student Support**

Panel – *Rita P. Ahrens, \* Asian & Pacific Islander American Scholarship Fund, 2025 M Street NW, Suite 610, Washington, DC 20036; rahrens@apiasf.org*

Rita Pin Ahrens will discuss how the model minority myth may have lasting impact on Asian and Pacific Islander American students both academically and in career opportunities. She will also address how groups like the Asian Pacific Islander American Scholarship Foundation (APIASF) and Asian American Native American Pacific Islander-serving Institutions (AANAPISIs) have worked to challenge these stereotypes and better support Asian and Pacific Islander American students to succeed in college and beyond.

\*Sponsored by David Marasco

**Session DK: Tracking, Mentoring, and Induction of New Teachers**

**Location:** Marriott Marquis - Scarlet Oak **Sponsor:** Committee on Teacher Preparation **Co-Sponsor:** Committee on Physics in High Schools **Time:** 8:30–10 a.m.  
**Date:** Tuesday, July 31 **President:** Scott Paulson

**DK01: 8:30-9:00 a.m. From Teacher Preparation to Professional Practice: Nurturing a Learning Community**

*Invited – Eugenia Etkina, Rutgers University, 10 Seminary Place, New Brunswick, NJ 08901-1183; eugenia.etkina@gse.rutgers.edu*

In this talk I will describe how the Rutgers Physics Teacher Preparation Program connects pre-service training to post-graduation professional development and practice. We use social networks and face-to-face meetings as two components of a professional learning community. I will show how one can maintain such a community with very little time investment and no additional funding. The learning community not only supports beginning teachers during their most difficult years of teaching and allows pre-service teachers to have high quality student teaching experience, but, most importantly, it allows practicing teachers to undergo continuous professional development. In addition, it inspires me to improve my craft. I will share the achievements of the community and the difficulties that arise. Rutgers has been producing large numbers of physics teachers for the past 14 years. Ninety percent of these teachers remain in the profession.

**DK02: 9:00-9:30 a.m. Tracking, Mentoring and Induction of New Physics Teachers at Brigham Young University**

*Invited – Duane B. Merrell, Brigham Young University, N-143 ESC, Provo, UT 84602; duane\_merrell@byu.edu*

Tracking, Mentoring, and Induction of New Teachers. Methods to develop relationships with and development of teachers after they leave your program. We see these students in our teacher preparation classes, we watch them graduate, we help them find jobs and we watch them grow as teachers. In many cases they become our mentor teachers for the preparation of our new groups of undergraduates, they still help the physics teachers program at BYU. Sometimes they call years later to find out if you can help them find a job. Many times the relationships you have built with the students become part of the State Science Teachers Association reunions. You should be going to a session but the time in the hall is more valuable to you and them. Later they start to be your go to teachers to plan and develop teacher professional development programs in the summer. Whatever the reason these students need to know that you understand and are there when they need you. The hard times are when the principal calls and has interviewed two or three of your students and wants to know who to hire. Oh the joys of having students you have worked with as undergraduates and now as teachers and the network that is formed that stays with you throughout yours and their time after graduation. They are real people, young physics teachers, and real things happen to them, good times, tough times, happiness, sadness, life and sadly even death. Oh the joys of being a university mentor for your graduated students.

**DK03: 9:30-10:00 a.m. Zen and the Art of Physics Teacher Mentoring**

*Invited – Jon P. Anderson, 2730 Pierce Street NE, Minneapolis, MN 55418; anderson.jon.p@gmail.com*

New physics teachers need mentoring! In addition to the need to know and understand their content, they need direction deciding upon appropriate demonstrations, analogies, examples, and labs, pacing of topics, seniors in the spring, classroom management, lab supply budgets, and much more. This talk will explore the role that mentors play in attracting new physics teachers, in helping them through those critical first years, and in retaining them in the physics teaching profession. Mentoring is one of the many roles that a Physics Teacher Education Coalition (PhysTEC) Teacher-in-Residence (TIR) fulfills. This talk will also address how TIRs from institutions around the country work as recruiters, mentors, and advocates for the profession of physics teaching. As a current physics teacher and a former mentee, I can speak to the value of all of these.



**Demo Show**  
**Tuesday, July 31**  
**8:30–9:30 p.m.**  
**Renaissance Ballroom**

## Session DL: Upper Division Undergraduate

Location: Meeting Room 10/11

Sponsor: AAPT

Time: 8:30–10:30 a.m.

Date: Tuesday, July 31

President: Toni D. Sauncy

### DL01: 8:30-8:40 a.m. Introducing Physics Innovation and Entrepreneurship (PIE) into First-year Physics\*

Contributed – Randall Jones, Loyola University Maryland, 4501 N. Charles St., Baltimore, MD 21210; rsj@loyola.edu

Bahram Roushani, Loyola University Maryland

The J-TUPP, Phys21 report reminds us that most physics bachelor graduates are employed outside academia and that important skills for these students include a creative ability to apply physics knowledge to real-world settings. We are introducing students to the ideas of innovation and entrepreneurship as a way to encourage them to think about applying their physics knowledge throughout their four-year physics program. In this presentation we report on how we introduce these ideas into a typical first-year course, without sacrificing a large proportion of course time. A subsequent presentation will discuss an upper-level course, offered to seniors, that goes into greater depth on innovation and entrepreneurship.

\*Support for this work is provided by the National Science Foundation's IUSE program under Award Number 1624882.

### DL02: 8:40-8:50 a.m. Introducing a Physics Innovation and Entrepreneurship (PIE) Course\*

Contributed – Bahram Roushani, Loyola University Maryland, 4501 N. Charles St., Baltimore, MD 21210; broughani@loyola.edu

Randall S. Jones, Loyola University Maryland

A new undergraduate physics course entitled, "Technical Innovation and Entrepreneurship" at Loyola University Maryland introduces students to the essential knowledge and skills guiding them from opportunity-recognition to developing a prototype via a semester-long team project. The structure of the course and the topics covered will be presented and the logistics of offering a cross-listed, project-based lecture course will be discussed. This course is designed to prepare students to be productive members of the innovation economy by providing a skill set required for success in tech-ventures and startups, or leading change within innovative organizations as an "intrapreneur." This course is developed through the NSF-supported PIPELINE\* project, and represents an example of implementing Physics Innovation and Entrepreneurship (PIE) education. The learning outcomes of this Technical Innovation and Entrepreneurship course is in alignment with the desired learning outcomes expressed in the JTPP's report entitled, "Phys21: Preparing Physics Students for 21st Century Careers."

\*Support for this work is provided by the National Science Foundation's IUSE program under Award No. 1624882.

### DL03: 6:20-6:30 p.m. N-Body Simulation of Planetary Dynamics

Contributed – Patrick Miles, Syracuse University, 5 Tremain Drive, Syracuse, NY 13210-3028; pmiles@syr.edu

Aaron Hutchins, Christopher Kane, Meghan Lentz, Walter Freeman, Syracuse University

Clusters of gravitationally-interacting objects display a wide range of interesting phenomena, and it is often very useful to construct numerical models of such phenomena. The computational cost of these models grows exponentially with the number of interacting objects, so approximations must be made to ensure that these simulations run in reasonable lengths of time. Implementation of a fast multipole method of evaluating gravitational forces allows these simulations to be run at low computational cost with minimal loss in accuracy. In this presentation I will discuss the algorithm I used to approximate the necessary force calculations, use this algorithm to model interesting planetary dynamics, and compare my simulation's results to actual observations.

### DL04: 9:00-9:10 a.m. N-Body Simulation of the Genesis of Earth's Moon

Contributed – Aaron T. Hutchins, Syracuse University, 6 Spindlerwick Drive, Nashua, NH 03062-4512; athutchi@syr.edu

The non-relativistic interaction of interstellar masses may be modeled as a time-evolving system composed of many particles obeying classical force laws. N-body simulations run more efficiently with the implementation of algorithms based on a rapid multipole method. Higher moments are implemented to decrease error per timestep. Collision dynamics are added to the simulation with the goal of modeling a numerically and visually accurate simulation of the formation of Earth's moon, which is hypothesized to have formed over 4.5 billion years ago following the collision of a proto-Earth with a Mars-sized body called Theia. The simulation in development models the collision, accretion disk formation, and eventual formation of the modern-day astronomical bodies.

### DL05: 9:10-9:20 a.m. Simulating Solar System Formation

Contributed – Christopher Kane, Syracuse University, 24 Maplewood Drive, West Monroe, NY 13167-3120; cfkane@syr.edu

Our solar system is believed to have formed from a molecular cloud that existed 4.6 billion years ago via gravitational collapse. In this work, I simulate a molecular cloud of  $10^5$  particles interacting according to Newton's law of gravity under a number of different initial conditions and collision dynamics. In order to speed up the simulation, I implement the fast multipole method to approximate the force on each particle and include up to the quadrupole moment to ensure the error in the force calculation remains small. Additionally, I implement the fourth order symplectic Omelyan integrator to solve the equations of motion with a large timestep. I present the solar systems that result from each scenario in search of the initial conditions that likely led to the formation of our own solar system.

### DL06: 9:20-9:30 a.m. Effect of Practice Exam on Undergraduate Modern Physics Course

Contributed – Suman Neupane, Middle Tennessee State University, 1301 E. Main St., Murfreesboro, TN 37132; Suman.Neupane@mtsu.edu

This study explores the impact of offering practice exam in a Modern Physics course offered at the sophomore level in a primarily undergraduate institution. Practice exams, of comparable rigor and length, were conducted outside the normal class meeting times, at least a weekend ahead of actual exam. The investigation shows that the performance of students participating in these optional practice exams was modestly better in actual exams as compared to non-participating students. The students who participated in these practice exams were able to get formative feedback about weakness and had additional time to rectify shortcomings which led to improved performance in the actual exam. Practice exams could also serve as an additional interaction period between the instructor and students and will be immensely beneficial for students who routinely do not use office hours.

### DL07: 9:30-9:40 a.m. Students' Construction of their Knowledge of Wave-Particle Duality\*

Contributed – Nilüfer Didis Körhasan, Bülent Ecevit University Bülent Ecevit Üniversitesi, Ereğli Eğitim Fakültesi (Doruk Binas) Ofis:211 Karadeniz Ereğli, Zonguldak, 67300 Turkey niluferdidis@gmail.com

Kelly Miller, Eric Mazur, Harvard University

Peer Instruction is an instructional methodology that allows students to reveal their own thinking about concepts through discussions with peers [1]. Many research studies have shown that Peer Instruction has a positive impact on students' physics problem solving skills, conceptual understanding, attitudes towards physics and physics self-efficacy [2, 3, 4, 5]. In this study, we examine how students construct mental models of wave-particle duality in a Peer Instruction environment. We collected observational and interview data, student reading annotation data, as well as students' responses to ConcepTests, and questionnaires. The results indicate students display four different mental models: Quantum Model (QM), Hybrid Model (HM), Wave Model (WM) and In-between Model (IM).

\*This research is supported by The Scientific and Technological Research Council of Turkey (TÜBİTAK).

1. Mazur, E. (1997). Peer Instruction: A User's Manual. New Jersey: Pearson & Prentice Hall. 2. Crouch, C. H., & Mazur, E. (2001). Peer Instruction: Ten years of experience and results. American Journal of Physics, 69(9), 970-977. 3. Lasry, N., Mazur, E., & Watkins, J., (2008). Peer instruction: From Harvard to community colleges. American Journal of Physics, 76, 1066-1069. 4. Miller, K., Lasry, N., Lukoff, B., Schell, J., & Mazur, E. (2014). Conceptual question response times in Peer Instruction classrooms. Physical Review Special Topics: Physics Education Research, 10(2), 020113. 5. Miller, K., Schell, J., Ho, A., Lukoff, B., & Mazur, E. (2015). Response switching and self-efficacy in Peer Instruction classrooms. Physical Review Special Topics: Physics Education Research, 11, 010104.

#### **DL08: 9:40-9:50 a.m. Comparing Chinese and American Students' Performance in Quantum Mechanics**

Contributed – *Guangtian Zhu, East China Normal University, School of Teacher Education, East China Normal University Shanghai, N/A 200062 China zhuguangtian@gmail.com*

This paper discusses a comparative study on the American and Chinese students' conceptual understanding of quantum mechanics. We administered the Quantum Mechanics Survey (QMS) to over 400 undergraduate students from 10 universities in China and the United States. The result showed that the students in the American universities had a better performance in the QMS compared to their Chinese peers.

#### **DL09: 9:50-10:00 a.m. Standards-based Grading in Advanced Undergraduate Physics Courses**

Contributed – *Deepak Iyer, Bucknell University, 153 Olin science building, Lewisburg, PA 17837; d.iyer@bucknell.edu*

I discuss applying a modified version of the "standards based grading" (SBG) system to an advanced undergraduate quantum mechanics course in a small classroom setting. The primary objective was to move away from exams, and implement a formative assessment system focused on student learning. SBG allowed incorporating assessment of nontraditional elements such as complex derivations, computational problems, and writing and project based activities into one system of standards in this theory oriented course. In this talk, I will describe my system of standards, my overall impressions, and anecdotal feedback from students.

#### **DL10: 10:00-10:10 a.m. Investigating Student Difficulties with the Corrections to the Energy Spectrum of the Hydrogen Atom for the Zeeman Effect**

Contributed – *Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu*

*Christof Keebaugh, Chandralekha Singh, University of Pittsburgh*

We discuss an investigation of student difficulties with the corrections to the energy spectrum of the hydrogen atom for the Zeeman effect using degenerate perturbation theory (DPT). The investigation was carried out in advanced quantum mechanics courses by administering free-response and multiple-choice questions and conducting individual interviews with students. We find that students share many common difficulties related to physics and mathematical sense making. We are using the research on student difficulties to guide the development of a Quantum Interactive Learning Tutorial (QuILT), which strives to help students develop a functional understanding of concepts necessary for finding the corrections to the energy spectrum of the hydrogen atom for the Zeeman effect using DPT.

#### **DL11: 10:10-10:20 a.m. A Research Experience-based Measurement Laboratory Course**

Contributed – *Gernot Laicher, University of Utah, Department of Physics & Astronomy, 115 South 1400 East # 201, Salt Lake City, UT 84112; gernot@physics.utah.edu*

*Clayton C. Williams, University of Utah, Department of Physics & Astronomy*

Universities can offer a science-based research experience to only a limited number of undergraduate students. We have started a one-semester lecture/lab course for advanced undergraduate students providing an "alternative research" experience to students who cannot engage with a full-fledged research group. The lecture is closely tied to the lab work and homework relates directly to measurements performed and systems built in the laboratory. Laboratory instructions are limited to essential goals, requiring active engagement of students. The course teaches measurement principles and physical sensors in semi-structured labs for seven weeks. Thereafter, the remaining weeks of the semester students work on self-created "research" projects/measurement challenges (one or two students together). Students propose the project early enough that parts can be ordered, establish milestones to be achieved along the way, assemble and build the apparatus, characterize its performance, and present results to class members.

#### **DL12: 10:20-10:30 a.m. Lessons Learned from REU Site in Physics at Howard University\***

Contributed – *Prabhakar Misra, Howard University, Department of Physics & Astronomy, Washington, DC 20059; pmisra@howard.edu*

*Silvina M. Gatica, Quinton L. Williams, Pratibha Dev, Thomas A. Searles, Howard University*

The NSF-funded REU Site in Physics at Howard University recruits six undergraduate students, typically sophomores and juniors, from across the U.S. for a 10-week cutting-edge research immersion in experimental, computational and theoretical condensed matter physics, optics and laser spectroscopy. The selected REU students are from diverse backgrounds and underrepresented in STEM. These students come especially from smaller institutions where there are limited opportunities and resources available for physics research, especially for advanced experimental physics investigations and computational simulations tied to complex physical phenomena. The talk will focus on lessons learned from past experiences with four REU cohorts, comprising of a total of 24 undergraduate students of varied backgrounds and demographics drawn from across the continental United States.

\*Financial support from the National Science Foundation Award Number PHY- 1659224 is gratefully acknowledged.

## Session DM: Writing in the Physics Curriculum: Objectives, Implementation, and Assessment

Location: Meeting Room 4    Sponsor: Committee on Physics in Undergraduate Education    Time: 8:30–10:30 a.m.    Date: Tuesday, July 31

President: Ramesh Adhikari

### DM01: 8:30-9:00 a.m. An Overview of Writing in the Physics Curriculum

*Invited – W. Brian Lane, Jacksonville University, 2800 University Blvd. N, Jacksonville, FL 32211; wlane@ju.edu*

Many physics graduates report that writing is important in their careers. Therefore, our students need to develop their writing skills within a variety of disciplinary contexts and not just in a freshman composition course. In all aspects of a physics course (problem solving, computational modeling, and laboratory projects), writing-infused assignments offer important insights into student understanding and reasoning that can be missed in strictly numerical assignments. However, there has been little formal development of writing in the physics curriculum. This presentation will establish the goals of this session, examine common institutional contexts for writing across the curriculum, survey current research and practices of incorporating writing into the physics curriculum, and explore possibilities for further development within the physics education community.

### DM02: 9:00-9:30 a.m. Self-Diagnosis: Writing to Assist Metacognition in Problem Solving

*Invited – Andrew Mason, Department of Physics and Astronomy, University of Central Arkansas, Lewis Science Center 171, Conway, AR 72035-0001; ajmason@uca.edu*

I discuss a study in which introductory-level students were explicitly induced in a one-time intervention to review their quiz solutions and “self-diagnose” mistakes, via written observations. Different groups of students respectively experienced different levels of scaffolding in this task; the degree to which they could diagnose their errors effectively in class are discussed. Effects on subsequent problem-solving attempts on a paired midterm problem are also presented, in which the degree of scaffolding is considered as a variable. Finally, as time permits, I will discuss a more recent study in which the self-diagnosis exercise was adapted to a weekly exercise for life science majors in an introductory physics course, specifically in the form of a pre-laboratory problem solving exercise. Additional variables were revealed by this study, e.g. student achievement goals and choice of life science major.

### DM03: 9:30-10:00 a.m. Supporting Students' Writing of Explanations in Introductory Physics Classes

*Invited – Stephen Robinson, Tennessee Technological University, TTU Box 5051, Cookeville, TN 38505; sjrobinson@tntech.edu*

*Edward Price, California State University, San Marcos*

*Paula Engelhardt, Tennessee Technological University*

*Fred Goldberg, Michael McKean, San Diego State University*

This presentation will discuss two different ways in which introductory physics students' skills in writing scientific explanations have been supported. First, the web-based Calibrated Peer Review (CPR) system (1) was used in a guided-inquiry, conceptual physics Learning Physics (LEP) course (2) for pre-service elementary teachers and general education students. This system engages students both in constructing their own explanations and in evaluating those of their peers. Students in classes that were engaged in a series of CPR assignments performed better on an end-of-course explanation task than those in classes that did not include this element. Second, an explicit ‘Explain the Physics’ step has been included in a problem-solving protocol developed specifically for the similarly structured Learning Environment for Algebra-based Physics (LEAP) curriculum materials (2). Students using this protocol are expected to support both diagrammatic and algebraic representations with associated narrative descriptions of physics ideas.

(1) <http://cpr.molsci.ucla.edu> (2) The development of both LEP and LEAP were supported by grants from the National Science Foundation

### DM04: 10:00-10:10 a.m. Technical Writing vs. Writing across the Curriculum and all Else

*Contributed – Richard H. Price, Massachusetts Inst of Tech-MIT, 77 Massachusetts Ave., Cambridge, MA 02139; rprice.physics@gmail.com*

There is ample evidence that our students cannot communicate in written or oral form, and there are ample reasons for this in the structure of undergraduate education. I will report on my experiences with three different experiments in teaching technical writing, at three very different universities. I will argue, on the basis of these experiences that: (i) Standard writing courses are ineffective for future scientists and engineers. (ii) Writing across the curriculum is ineffective. (iii) Physicists must teach physics students how to write. (iv) Teaching writing is much more expensive in faculty time than is teaching typical physics courses, so no improvement will be made until there is a much greater appreciation for the importance of technical writing. (v) Technical writing should be part of a course in “professional preparation” that also includes other elements of students' post-undergraduate careers.

### DM05: 10:10-10:20 a.m. Developing a Scientific Writing Framework for Students in Introductory Physics

*Contributed – Jacob Capps, United States Military Academy, Bartlett Hall Science Center, West Point, NY 10996; jacob.capps@usma.edu*

*William M. Meier, Corey S. Gerving, United States Military Academy*

The ability to write and communicate effectively is essential for future scientists. Recently, the United States Military Academy (USMA) invested in developing written communication skills at varying stages in student development. The West Point Writing Program (WPWP) requires developmental writing exercises both in the core curriculum and within the major of each graduate. The Department of Physics and Nuclear Engineering is the proponent for one of the writing courses: Introductory Physics II. By using writing events of increasing difficulty, students learn how to write technical reports over the course of a semester. The process culminates with the Signature Writing Event (SWE), which is a two-hour partial laboratory report on an experimental data collected during the previous lab period.

Talk presented by Jacob Caps. Sponsor for this presentation is Corey Gerving (AAPT Member).

### DM06: 10:20-10:30 a.m. A Scaffolded Approach to Writing Across the Physics Curriculum

*Contributed – Joseph F. Kozminski, Lewis University Physics Department, One University Pkwy Romeoville, IL 60446; kozminjo@lewisu.edu*

Developing students' ability to write in forms authentic to the discipline is an outcome listed in the AAPT Recommendations for the Undergraduate Laboratory Curriculum. The Physics Department at Lewis University has recently implemented a revised curriculum that develops students' scientific writing skills in a scaffolded way from the introductory labs through a capstone project. The curriculum gives students experience writing in several different styles, including literature reviews, proposals, and journal-style articles, and includes opportunities for review and revision. This presentation will discuss how writing is integrated into the curriculum and the types of writing covered.



**Kyle Forinash**  
Indiana Univ. Southeast  
New Albany, IN

### **Breaking Out of the Physics Silo, by Kyle Forinash, Millikan Medal Winner**

According to his autobiography, Robert Millikan became a physics teacher when his Greek professor at Oberlin College asked him to teach a preparatory class in physics at the college. I'm sure this was not an easy transition for Millikan but the world is better off for him having been obliged to venture into unfamiliar territory. Most of us would prefer to stay within our comfort zone, especially in the classroom. But sometimes we decide (or are forced, kicking and screaming) to try something new that can make us flourish as teachers. Millikan had good advice for anyone faced with a new challenge: "All right, said I, you will have to take the consequences, but I will try and see what I can do with it." In this presentation I will offer some suggestions, grounded in fortuitous events that have caused me to grow as a teacher, for ways to take risks, leave the physics silo and learn new things. Your teaching will be better for it.

### • **Homer L. Dodge Citations for Distinguished Service**

Ximena Cid, Jose D'Aruda, Joy Elaine Gwinn, Warren Hein, and David Jackson

### • **2018 AAPT Fellows**

Brad Ambrose, Kathleen Falconer, Kyle Forinash III, Dan MacIsaac, Jitendra Sharma, John Stewart, and Gay Stewart

### • **John W. Layman and John L. Hubisz Remembrance**

*Speakers: Aaron Titus, for John Hubisz*

*Jack Hehn, for John Layman*

### **Session EA: PER: Cognition, Meta-cognition, Reasoning**

**Location:** Congressional Ballroom A **Sponsor:** AAPT/PER **Time:** 1:30–3:30 p.m. **Date:** Tuesday, July 31 **President:** AJ Richards

#### **EA01: 1:30-1:40 p.m. Dual Process Theory as a Lens for Probing Physics Reasoning\***

*Contributed – Brianna Santangelo, North Dakota State University, 1340 Administration Ave., Fargo, ND 58102; brianna.santangelo@ndus.edu*  
*Mila Kryjevskaja, North Dakota State University*

Research has revealed that even after targeted instruction, many students still struggle to analyze unfamiliar situations systematically. Students tend to rely on intuitive reasoning instead of applying formal knowledge and skills acquired as a result of instruction. In order to pinpoint specific factors and instructional circumstances that lead to productive and unproductive reasoning strategies, we have been developing and implementing sequences of questions that allow for the disentanglement of student conceptual understanding, reasoning, and intuition. The Dual Process Theories of reasoning are used to interpret the results. Student responses from one such sequence of questions in the context of introductory Mechanics course will be presented. Implication for research and instruction will be discussed.

\*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432052, DUE-1432765.

#### **EA02: 1:40-1:50 p.m. Leveraging Dual-Process Theories of Reasoning to Impact Student Performance\***

*Contributed – J. Caleb Speirs, University of Maine, 19 Getchell St., Brewer, ME 04412; caleb.speirs@gmail.com*

*MacKenzie R. Stetzer, University of Maine*

*Beth A. Lindsey, Penn State Greater Allegheny*

*Mila Kryjevskaja, North Dakota State University*

As a component of a multi-year, multi-institution collaboration aimed at investigating and assessing the development of student reasoning skills in physics, we have designed an online "chaining" task to examine student skill at generating qualitative, inferential reasoning chains. In these chaining tasks, students are provided with correct reasoning elements (i.e., true statements about the physical situation as well as correct concepts and mathematical relationships) and are asked to assemble them into an argument to answer a physics problem. In particular, we have drawn upon dual-process theories of reasoning to design an intervention in which a single reasoning element is added in order to support the productive engagement of the analytic process (system 2). In this talk, we describe results from this investigation and situate them within a dual-process-based framework for student reasoning in physics.

\* This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DRL-0962805.

**EA03: 1:50-2:00 p.m. Probing the Nature of Student Reasoning Using Modified Chaining Tasks\***

Contributed – MacKenzie R. Stetzer, University of Maine, 5709 Bennett Hall, Room 120, Orono, ME 04469-5709; mackenzie.stetzer@maine.edu

Ryan P. Moyer, J. Caleb Speirs, University of Maine

Beth A. Lindsey, Penn State Greater Allegheny

As part of a larger effort to investigate and characterize the nature of student reasoning in physics, we have been designing tasks that examine student ability to generate qualitative, inferential reasoning chains. In an online “chaining” task, students are provided with correct reasoning elements (i.e., true statements about the physical situation as well as correct concepts and mathematical relationships) and are asked to assemble them into an argument in order to answer a physics problem. In a modified version of the task, students are first asked to categorize these reasoning elements as being useful or not useful for solving the problem. Data from these modified tasks provide further insight into the extent to which some reasoning phenomena in physics may be accounted for by dual-process theories of reasoning and decision-making.

\* This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DRL-0962805.

**EA04: 2:00-2:10 p.m. Impact of Cognitive Reflection Skills on Student Reasoning in Physics\***

Contributed– Mila Kryjevskaja, North Dakota State University, Department of Physics, PO Box 6050, Fargo, ND 58108-6050; mila.kryjevskaja@ndsu.edu

MacKenzie R. Stetzer, University of Maine

Andrew Boudreaux, Western Washington University

According to dual-process theories of reasoning, human cognition occurs through two thinking processes: a fast, automatic, intuitive Process 1 and a slow, deliberate, analytic Process 2. The reasoner first develops a mental model of an unfamiliar situation through the fast and intuitive Process 1 and only then may the analytical Process 2 intervene to assess the validity of the first available mental model. As such, it is critical to understand the mechanisms that allow reasoners to mediate intuitive thinking via more analytical reasoning. The Cognitive Reflection Test (CRT) has been developed in psychology to gauge the tendency of a reasoner to engage the analytic process in order to evaluate the output of the intuitive process. In this talk, we describe the results of our research using the CRT to probe the complex relationships among cognitive reflection, conceptual understanding, reasoning, intuition, and student performance in physics.

\* This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DRL-0962805.

**EA05: 2:10-2:20 p.m. The Relationship Between Cognitive Reflection and Performance in Physics\***

Contributed – Cody R. Gette, North Dakota State University, 1211 Albrecht Blvd., Fargo, ND 58105; cody.gette@ndsu.edu

Mila Kryjevskaja, North Dakota State University

MacKenzie R. Stetzer, University of Maine

Andrew Boudreaux, Western Washington University

Dual-process theories of cognition suggest that many inconsistencies in student reasoning in introductory physics may stem from a fast, automatic, and intuitive process interfering with slow and analytical thinking. The Cognitive Reflection Test (CRT) has been developed in psychology to gauge the tendency of a reasoner to engage analytical thinking to evaluate (and possibly override) these initial intuitive ideas. In our ongoing, multi-institutional project, we have been exploring the applicability of the CRT to probe the relationship between cognitive reflection and performance in physics (as measured, for example, by the Force and Motion Conceptual Evaluation, or FMCE). Results from our investigation as well as implications for instruction will be discussed.

\*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DRL-0962805.

**EA06: 2:20-2:30 p.m. The Cognitive Accessibility Rule: Reasoning with Alternative Explanations**

Contributed –Andrew F. Heckler, The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; heckler.6@osu.edu

Abigail M. Bogdan, Seton Hill University

A critical component of scientific reasoning is the consideration of alternative explanations. Given that decades of cognitive psychology research have demonstrated that relative cognitive accessibility, or “what comes to mind,” strongly affects how people reason, we articulate a simple “cognitive accessibility rule”: Alternative explanations are considered less frequently when relatively high accessibility factors are offered as the explanation. We test the cognitive accessibility rule in the context of consideration of alternative explanations for six physical scenarios commonly found in introductory physics curricula. First we administer free recall and recognition tasks to empirically establish the relative accessibility of common explanations for the physical scenarios. Then we offer either high or low accessibility explanations for these physical scenarios and determine the extent to which students consider alternatives to the given explanations. Overall, we find the cognitive accessibility rule is strongly predictive, and can help to explain biases in considering alternative explanations.

**EA07: 2:30-2:40 p.m. Student Cognition in Physics Group Exams**

Contributed – Timothy Malcolm Sault, East Carolina University, 2706 Stantonsburg Rd., Apt. 1B, Greenville, NC 27834-7269; Timsault@gmail.com

Hunter G. Close, Texas State University

Steven F. Wolf, East Carolina University

When grading exams, professors often wonder ‘why are they getting this wrong?’, ‘how did they get that answer?’, or ‘are they just guessing?’ However, when viewed from a pedagogical perspective, the correct answer is never the most interesting one. When answering a single question, a single misconception may be identified, but with ‘chains’ of multiple questions on the same subject, students’ logical consistency is assessed, and conceptual contradictions may arise. Given adequate time in a group collaboration environment, we believe that students’ ability to process and overcome deeply nested misconceptions and sustain consistent logic will improve.

**EA08: 2:40-2:50 p.m. Investigating Factors that Affect Student Ability to Follow Reasoning Chains\***

Contributed Beth A. Lindsey, Penn State Greater Allegheny, 4000 University Dr., McKeesport, PA 15132; bal23@psu.edu

MacKenzie R. Stetzer, J. Caleb Speirs, University of Maine

William N. Ferm Jr., Ellsworth High School



As part of a multi-institution collaboration, we are examining students' multi-step, qualitative reasoning in physics. One aspect of interest is the extent to which students are able to follow and infer conclusions from reasoning chains that have been provided to them. In order to explore this issue, we have developed a collection of tasks that are administered online to large populations of students in introductory calculus-based courses. We examine student success rates at inferring conclusions from the provided reasoning chains as well as the factors that may affect these success rates. The implications of our results for instruction and curriculum development will be discussed.

\*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DRL-0962805.

### **EA09: 2:50-3:00 p.m. Use of Eye Tracking to Examine Student Attention During Programming**

*Contributed – W. Brian Lane, Jacksonville University, 2800 University Boulevard North, Jacksonville, FL 32211; wlane@ju.edu*

*Daniel Furnas, Ramesh Adhikari, Jacksonville University*

One of the challenges that arises when teaching scientific programming is encouraging students to focus on the most salient features of a code. This difficulty is similar to challenges encountered when students read a scientific textbook. A preliminary study (Malysheva, et al, 2015) has explored student reading of a physics textbook using an eye tracker, revealing that students engage in different reading patterns depending on whether they are reading through a physics text or searching a physics text for answers to pre-established questions. Such differences likely extend to student programming activities. We conduct a similar study by asking participants to perform various scientific programming activities (from reading a code to modifying a code to perform additional functions) and using an eye tracker to record participant eye behaviors during these activities. Measurements of student areas of interest and scanpaths within the code help us examine how students cognitively process these activities.

### **EA10: 3:00-3:10 p.m. Using Eye Tracking to Identify Instructive Features of Diagrams**

*Contributed – Raymond Zich, Illinois State University, Physics Department, Campus Box 4560, Normal, IL 61790-0001; rlzich@ilstu.edu*

*Rebecca Rosenblatt, Amber Sammons, Illinois State University*

Visual representations play an essential role in the learning of physics. Grounded cognition suggests that visual perception activates perceptual symbols that are the basic cognitive units from which the brain constructs knowledge. Under this theory effective diagrams activate perceptual symbols that facilitate the construction of the correct physics concepts. Eye tracking technology was used to investigate student gaze patterns in a number of standard physics diagrams compared to modified diagrams that used changed color and size to perceptually enhance the diagrams. Students were presented with diagrams representing fluid flow in pipes and venturils, motion maps, and equipotential lines. For each diagram they were asked ranking questions about displayed variables at selected places. Eye tracking data was used to establish which elements of these instructional diagrams are necessary for success in the ranking tasks, if these elements are consistent across different diagrams, and if these elements change for perceptually modified diagrams.

### **EA11: 3:10-3:20 p.m. Accuracy of Metacognitive Predictions in an Introductory Physics Course**

*Contributed – Jason W. Morphew, University of Illinois at Urbana-Champaign, 1110 West Green St., Champaign, IL 61822; jmorphe2@illinois.edu*

*Jose P. Mestre, University of Illinois at Urbana-Champaign*

Students must determine how to effectively allocate his or her time in studying for upcoming midterm exams. Prior research has found that low-performing individuals overpredict their performance, while high-performing students underpredict. This suggests that metacognitive skills are linked to ability. However metacognitive monitoring has also been found to be related to the goals, motivations, and epistemological beliefs in models of self-regulated learning. In other words, not all low-performing students demonstrate a lack of metacognitive monitoring accuracy. In this study, students enrolled in an introductory algebra-based mechanics course predicted their exams scores on all four exams and completed surveys about their epistemological beliefs and academic goal orientations. Preliminary results indicate that high-performing students are more accurate at predicting their exam performance, that their beliefs and goal orientations are not related to metacognitive accuracy, and that receiving feedback about the accuracy of their predictions do not affect exam performance or metacognitive accuracy.

### **EA12: 3:20-3:30 p.m. Metacognitive Discourse in a STEM Experiential Program: A Video Analysis**

*Contributed – Ying Cao, Oregon State University, Oregon State University, Gleeson Hall 105, Corvallis, OR 97331-8507; caoyin@oregonstate.edu*

*Amreen Thompson, University of Colorado Denver*

*Jenay Serman, Florida State University*

*Aikaterini Mari,*

*Fidel Amezcua, Chicago State University*

Metacognition supports student learning in STEM learning contexts. However, research is needed to examine metacognitive talk in classroom learning discourse. We have focused on a 33-minute, small group activity in a university bridge program where four freshmen students discussed about an article on growth and fixed mindset with instructor intervention in the middle of the discussion. We used iterative emergent coding to categorize metacognitive talk in discourse. We developed metacognitive talk categories in the mindset activity and related those to existing frameworks about metacognitive discourse. We then did a frequency analysis on the codes. We found that metacognitive talk in the group doubled in frequency following instructor interaction. The types of metacognitive talk also changed after instructor intervention. Future research will look at a different activity (e.g., authentic scientific inquiry) and categorize metacognitive talks in that context. We aim at reporting a contrasting case study about student metacognitive talk categories.

## Session EB: Cutting-Edge Educational Technology From Europe

Location: Marriott Marquis - Magnolia Sponsor: Committee on International Physics Education Co-Sponsor: Committee on Educational Technologies

Time: 1:30–3 p.m. Date: Tuesday, July 31 President: Wolfgang Christian

### EB01: 1:30-2:00 p.m. Creating Tech-Savvy Simulations with EJS

Invited – Francisco Esquembre, \* Universidad de Murcia, Facultad de Matemáticas, Murcia, 30071 Spain fem@um.es

Félix García-Clemente, Universidad de Murcia

Educational technologies change rapidly, and these changes offer new opportunities for innovative teaching. Isolated educators can find it difficult to keep up, but collaborative development and teaching communities that use standard open source tools can benefit from these technical advances. Easy Java/JavaScript Simulations, EJS ([www.um.es/fem/EjsWiki](http://www.um.es/fem/EjsWiki)), is a modelling and authoring tool that allows teachers to create, adapt, and share instructional simulations in Java or JavaScript. EJS transforms a high-level specification of a physics simulation into code that uses the latest technological advances, including ePub 3, eBooks, Android or iOS Apps, and, soon, Progressive Web Applications. This talk shows how ready-to-use, tech-savvy products can be created from any JavaScript EJS simulation, and -- as a result -- how EJS-generated Apps can run on all devices and even access mobile device sensors. The Open Source Physics collection at the AAPT-ComPADRE digital library hosts hundreds of these EJS-based simulations created by and for physics teachers. Examples will be shown.

\*Sponsored by André Breges

### EB02: 2:00-2:30 p.m. Promoting IBL Exploiting New Pervasive Technologies

Invited – Giovanni Organtini, Sapienza Università di Roma & INFN-Sez. di Roma, Piazzale Aldo Moro 5, ROMA, RM 00185 Italy giovanni.organtini@uniroma1.it

The advent of new pervasive technological devices made precision physics accessible to mostly everyone at affordable costs. Smartphones allow the usage of their sensors as measurement tools: in fact, they are equipped with microphones, cameras, and accelerometers. Often, a magnetometer or gyroscopes are available, too. The Arduino project, on the other hand, made electronics accessible to everyone able to write a few lines of code. In order to promote Inquiry Based Learning, we recently designed a three days activity for physics teachers to allow them to exploit both of these technologies to perform precise, but simple and informative experiments for their classes. Our “school of physics with Arduino and smartphones” turns a teacher with no experience in programming and electronics into a real maker, able to design, build and execute experiments with exceptional performance at a very affordable cost. In this talk we describe how the school is organised and we report on the first, extremely encouraging results.

### EB03: 2:30-3:00 p.m. ~~CANCELLED~~ The Technology Enhanced Textbook: Introducing an HTML5-based Online System for Authors, Teachers and Learners and its Application Possibilities in Teacher Training

Invited – Rene Dohrmann, Freie Universität Berlin, Fachbereich Physik, Didaktik der Physik, Arnimallee 14, Berlin, Berlin D-14195 Germany rdohrmann@zedat.fu-berlin.de

Jürgen Kirstein, Sebastian Haase, Volkhard Nordmeier, Freie Universität Berlin, Fachbereich Physik, Didaktik der Physik

For many years there has been a great amount of multimedia content available for teaching physics, e.g. simulations, interactive screen experiments or remote laboratories. Here we introduce a platform that enables authors to include these tools into self-contained, rich learning materials. Furthermore, the system supports personalized work experience and active learning for students with these materials. By eliminating the boundaries between authors and learners, the Technology Enhanced Textbook (TET) motivates students as well as teachers to adapt their learning materials to their individual requirements. Additionally, TET is also used as an interactive platform for content that is part of teacher training programs. Recently, we added the FOCUS video portal that contains video vignettes helping future teachers to develop their professional knowledge. We will also discuss the use of TET in the teaching and learning labs of the Free University of Berlin.

## Session EC: Experimental Design at All Levels

Location: Marriott Marquis - Cherry Blossom Sponsor: Committee on Laboratories Co-Sponsor: Committee on Apparatus Time: 1:30–3:10 p.m.

Date: Tuesday, July 31 President: Joseph Kozminski

### EC01: 1:30-1:40 p.m. Design and Redesign of Acoustic Experiments

Contributed – Ashley R. Carter, Amherst College, Merrill Science Center, Amherst, MA 01002-5000; acarter@amherst.edu

Allowing students to design an experiment and iterate on that design to get better results provides an authentic lab experience. However, advanced and intermediate laboratory experiments are often so complicated that there is no opportunity for students to design experiments. Exceptions to this rule seem to be in optics and electronics experiments. Here we add another type of experiment to this list—acoustic experiments. Acoustics is used in ultrasounds, sonars, in back-up sensors for cars, in grouping cells together for tissue engineering, in seismology, and in architecture. Experiments can be made from piezo transducers (speakers) that are often lying around the undergraduate physics laboratory and require few parts, allowing students to design, build, and iterate in a single lab period. Here we present several acoustic experiments that give students an opportunity to design and re-design.

### EC02: 1:40-1:50 p.m. Goal-Focused Design in an Introductory Lab Course

Contributed – Nathan D. Powers, Brigham Young University, BYU Dept of Physics and Astronomy, N490 ESC, Provo, UT 84602; ndp5@byu.edu

An important part of design is maintaining an understanding of and focus on the goals of a project. This comes more naturally when students set and seek to accomplish their own goals. I have adapted an introductory lab course to include significantly more student design, including a culminating student-designed project for which both the goals and design are chosen by the student. Each week students attend a workshop which allows them to separate design and implementation. In the workshops, students can compartmentalize pieces of the overall design, set incremental goals, and design around those goals in a collaborative environment.

### EC03: 1:50-2:00 p.m. Transforming Introductory Physics Labs: Implementing Scientific Reasoning Instruction\*

Contributed – Larry J. Bortner, University of Cincinnati, 2825 Campus Way, Braunstein 345, Cincinnati, OH 45221; bortnelj@ucmail.uc.edu

Kathleen Koenig, Krista E. Wood, University of Cincinnati

Lei Bao, The Ohio State University

Lindsay Owens, Rochester Institute of Technology

Two general findings have spurred a change in the lab curriculum at the University of Cincinnati. One is that traditional introductory physics labs do not necessarily support student learning of lecture content. The other is that the critical thinking skills of college graduates are not necessarily enhanced as a result of their undergraduate studies. To increase the scientific reasoning skills of students, in 2014 we introduced the Inquiry for Scientific Thinking and Reasoning (iSTAR) labs that involve both a skills-based framework focused on specific reasoning domains and the deliberate practice of each. An example of how to use the iSTAR lab framework to transform a traditional lab to one that emphasizes scientific reasoning will be given. Challenges to implementation will be discussed including training instructors. Results will be shared for student improvement for ability to control variables, measured through staggered post-testing, which is useful in curriculum development.

\*This research is supported by NSF DUE-1431908.

#### **EC04: 2:00-2:10 p.m. From Traditional to Scientific Reasoning Labs in Introductory Physics\***

Contributed – Krista E. Wood, University of Cincinnati, 9555 Plainfield Rd., Cincinnati, OH 45236; [Krista.Wood@uc.edu](mailto:Krista.Wood@uc.edu)

Kathleen Koenig, Larry Bortner, University of Cincinnati

Lindsay Owens, Rochester Institute of Technology

Lei Bao, The Ohio State University

Learning outcomes recommended by AAPT focus on designing experiments, analyzing and visualizing data, modeling, and communicating physics. These scientific abilities require strong scientific reasoning skills, including the ability to design controlled experiments, collect and interpret empirical evidence, make claims based on that evidence, and support claims with scientific reasoning. Scientific reasoning (SR) skills have been shown to correlate with students' ability to learn concepts and engage in higher levels of problem solving. We implemented introductory physics labs, called Inquiry for Scientific Thinking and Reasoning (iSTAR) Labs that focused on developing students' SR skills. This talk will discuss the implementation of iSTAR Labs at a two-year college, the challenges and benefits of adopting iSTAR Labs for students and instructors, and suggestions for developing the instructor skills needed to effectively teach guided inquiry-based lab curriculum. We will also discuss the effect of iSTAR Labs on students' SR skills.

\*This research is supported by NSF DUE-1431908.

#### **EC05: 2:10-2:20 p.m. So How Do You Guys Do Labs?**

Contributed – Alex McKale, Stanford OHS, 220 Panama St., Stanford, CA 94305; [amckale@stanford.edu](mailto:amckale@stanford.edu)

Marie Hamaoui, Gary Oas, Stanford OHS

The Stanford Online High School has been around for 12 years and the single most common question is around how we do lab work. In this session we will share lessons learned and secrets that can be applied just as well to a traditional brick and mortar lab space. You may already go outside to the football field or the gym to measure the speed of sound. We just take it up a notch. Because the instructor is not present to make observations during the experiment, students need to conduct their work with much more independence and creativity. It also challenges the instructor to be creative in developing lab assignments. Lab write-ups (including videos, photos, and sound recordings) and lab notebooks become more critical to demonstrate what the student has done. We will help free you from the four walls of your current lab space.

#### **EC06: 2:20-2:30 p.m. Enhancing Students' Conceptual Understanding of Fundamental Physics through Scientific Argumentation**

Contributed – Jianlan Wang, Texas Tech University, 3008 18th St., Lubbock, TX 79409; [jianlan.wang@ttu.edu](mailto:jianlan.wang@ttu.edu)

One problem in physics education is overemphasizing mathematical manipulation over conceptual understanding. Consequently, students across all grade levels are likely to learn physics through "plug and chug". They may calculate the right answer without understanding what the number means. In this study, I will share the design of two labs in a row targeting two challenging topics in physics: reference frame and gravitational potential energy. The first lab is about the relative nature of motion and the second one is about the zero point of gravitational potential energy. Structured inquiry and scientific argumentation are the main instructional strategies. I will present the implementation of the two labs in a 7th grade class and discuss how they can be scaled up to the level of high school. Student data will also be included as evidence supporting the effectiveness of the labs.

#### **EC07: 2:30-2:40 p.m. Development of Scientific Abilities through Lab Reform**

Contributed – Joshua Rutberg, Rutgers University, 10 Seminary Place, New Brunswick, NJ 08901; [joshua.rutberg@rutgers.edu](mailto:joshua.rutberg@rutgers.edu)

Marina Malysheva, Eugenia Etkina, Rutgers University

Traditional physics labs have been shown to have little effect on the development of students' scientific abilities. Reformed labs, such as ISLE-based labs, have been shown to improve these outcomes when used in conjunction with trained TAs and a course emphasizing the ISLE framework. We studied a physics course for engineering students utilizing ISLE labs within a traditional lecture-based course that did not follow ISLE. We scored student lab reports using scientific abilities rubrics and found that while students improved their abilities to design an experiment, to investigate a phenomenon, to identify patterns in the data, and to communicate what they did, they had trouble explaining the patterns and communicating the purpose of the experiment. We will compare these findings to the findings of student learning in ISLE-based labs in other courses.

#### **EC08: 2:40-2:50 p.m. Implementing Research Skill Elements in Introductory Physics Laboratory**

Contributed – Changgong Zhou, 21000 West Ten Mile Rd., Southfield, MI 48075-1058; [czhou@ltu.edu](mailto:czhou@ltu.edu)

Research skill is a rich skill set. Even though not everyone needs research skill in his/her professional or personal life, some elements of research skill are essential for everybody's life, such as critical thinking, ambiguity tolerance, etc.. In the redesign of our introductory physics laboratory curriculum, one of the goals is to help students foster such element skills by letting them make use of the skills voluntarily. This presentation will showcase a few experiment samples, discuss the design philosophy and the impact on students behavior and learning.

#### **EC09: 2:50-3:00 p.m. Design and Implementation of a Cell Phone Detector**

Contributed – Oladayo Oyeneke, Block 793 Flat 3, Abesan Estate Ipaja, Lagos +234 Nigeria [oladayooyeneke@gmail.com](mailto:oladayooyeneke@gmail.com)

Oluseyi Obafemi

This work is capable of detecting incoming and outgoing signals from mobile phones. The presence of an activated mobile phone can be detected by this handy, pocket-size mobile signal detector from a distance of one and a half meters, which could be used in preventing the use of mobile phones in examination halls, confidential rooms etc. It is also suitable for detecting the use of mobile phone for spying and unauthorized video transmission. The circuit can detect the incoming and outgoing calls, text messages, and video transmission even if the mobile is kept in the silent mode. The moment the gadget detects Radio Frequency (RF) transmission signal from an activated mobile phone, it starts sounding a beep alarm and the Light Emitting Diode (LED) blinks. The alarm continues until the signal transmission ceases.

**EC10: 3:00-3:10 p.m. The Myth of the \$100 Detector**

*Contributed – Ian G. Bearden, Niels Bohr Institute, Blegdamsvej 17, Copenhagen, 2100 Denmark bearden@nbi.dk*

It is possible to find several sources (including the author) of so-called \$100 detectors for, eg, muons, gamma rays, and other radiation sources. I will discuss what it actually takes to build a working detector and how it is that we can claim to build them for such low cost. It turns out that one often needs to be able to buy in quantities that can be financially prohibitive, to have access to an unusual amount of technical know-how, and that a basement full of old equipment brings costs down substantially. The unfortunate realities of limited budgets thus impose severe constraints on including such detectors in student experiments.

**Session ED: Frontiers of Astronomy**

**Location:** Marriott Marquis - Dogwood    **Sponsor:** Committee on Space Science and Astronomy    **Time:** 1:30–3:30 p.m.    **Date:** Tuesday, July 31  
**President:** Richard Gelderman

**ED01: 1:30-2:00 p.m. Scientific Visualization at NASA: LRO and the Eclipse**

*Invited – Ernest Wright, \* USRA/NASA, NASA GSFC, Mail Code 606.4, 8800 Greenbelt Road, Greenbelt, MD 20771-0003; ernest.t.wright@nasa.gov*

The Scientific Visualization Studio (SVS) at NASA Goddard Space Flight Center uses data from NASA missions to produce animations and illustrations for education and public outreach. Its Web site contains over 6000 pages of media covering a wide variety of topics in Earth and space science. All of this material is freely available, and most is in the public domain. The process of creating visualizations at the SVS will be illustrated using the data returned by the Lunar Reconnaissance Orbiter spacecraft and the mapping of the total solar eclipse of August 21, 2017.

\*Sponsored by Richard Gelderman, Western Kentucky University. SVS: <https://svs.gsfc.nasa.gov>

**ED02: 2:00-2:30 p.m. Cassini's 13-Year Journey in the Saturn System**

*Invited – Carrie Anderson, \* NASA Goddard Space Flight Center, 8800 Greenbelt Rd., Greenbelt, MD 20771; carrie.m.anderson@nasa.gov*

The legacy of NASA's Cassini mission began in October 1997, marking its launch to begin a 7-year cruise to the Saturn System. Decades earlier, the Pioneer 11, followed by the Voyager 1 and 2 flybys, provided a mere glimpse into the Saturn System discoveries lying in wait for the magnificent 13-year Cassini mission. Cassini was the first spacecraft to orbit Saturn, enabling a much-anticipated detailed study of Saturn's environment – this includes its atmosphere, magnetosphere, extensive ring system, and 62 moons. Such discoveries include an in-depth study of Titan's atmosphere and surface, a moon that possesses Earth-like processes, as well as the small moon Enceladus, which has an active south polar region jetting icy material into space. In this presentation, an overview of the Cassini science discoveries will be given, along with a more detailed account of the discoveries made by the Composite InfraRed Spectrometer (CIRS), especially in regards to Titan.

\*Sponsored by Richard Gelderman

**ED03: 2:30-3:00 p.m. Exploring the Solar System with the James Webb Space Telescope**

*Invited – Heidi B. Hammel, \* AURA, 1331 Pennsylvania Ave NW, Suite 1475, Washington, DC 20004; hbhammel@aura-astronomy.org*

NASA's next Great Observatory will be the James Webb Space Telescope, planned for launch in 2019. As a successor to the venerable Hubble, Webb's science goals range from seeing the first stars in the Universe, to the studying the evolution of galaxies, to examining objects right in our own solar neighborhood. Dr. Hammel is one of the six Interdisciplinary Scientists chosen by NASA for this mission. Her program will use Webb to explore many objects in our Solar System, including Mars, Jupiter, Pluto, Neptune, comets, asteroids, and more. She will give a brief status review of the telescope, and highlight some of the key science results to expect. She will also touch on the astronomy community's plans for even more amazing space telescopes in the future.

\*Invited by Richard Gelderman (Western Kentucky University)

**ED04: 3:00-3:30 p.m. Reconnection Tames Turbulent Magnetic Fields Around Earth**

*Invited – Amy Rager, Catholic University, 620 Michigan Ave NE, Washington, DC 20064; amy.c.rager@nasa.gov*

Magnetic reconnection is a change in magnetic topology that causes the rapid transfer of magnetic energy into plasma particle kinetic energy. Reconnection has been the driving explanation for the injection of solar wind plasma, momentum, and energy into the Earth's magnetosphere, resulting in phenomena such as aurora and substorms. The Magnetospheric Multiscale (MMS) mission is designed to be able to observe the rapid reconnection of magnetic field lines at the dayside magnetopause. The Fast Plasma Investigation (FPI) instrument onboard MMS is able to detect the distribution of particles and their velocities in space with an unprecedented hundred-fold improved rate over prior missions, which have had to rely on the relatively slow spacecraft rotation time. We present a new technique for using the FPI instrument design to generate data with an added 4x greater time resolution and discuss the scientific discoveries made possible with this new data product.

## Session EE: Improving Accessibility for Physics Students with Visual or Cognitive Disabilities

Location: Marriott Marquis - Silver Linden Sponsor: Committee on Laboratories Co-Sponsor: Committee on Diversity in Physics Time: 1:30–3:30 p.m.

Date: Tuesday, July 31 President: Dimitri Dounas-Frazer

### EE01: 1:30-3:30 p.m. A Hands-on, Nonvisual Approach to Accessible Intermediate Physics Laboratory Courses

Invited – Paul Thorman, 370 Lancaster Ave., Haverford, PA 19041; pthorman@haverford.edu

Daniel Gillen

The undergraduate physics laboratory should be an environment where students interact directly with experimental materials, but students with blindness or impaired vision have often been left out of planning for lab courses. Design philosophies for laboratory courses with accessibility in mind are not common knowledge, and will be explored in our session. This presentation gives an overview of the experience and lessons learned from accommodating a blind student (one of the presenters) in an intermediate laboratory course at Haverford College. We will share details of some of our visual disability accommodations, which can enhance the essential hands-on nature of lab courses and improve student learning of core physical concepts.

### EE02: 1:30-3:30 p.m. Navigating the Hidden Politics of Making Real Change

Invited – Kyle Michael Keane, MIT - Massachusetts Institute of Technology, 77 Massachusetts Ave 13-4057, Cambridge, MA 02135; physics@kylekeane.com

Heman Gharibnejad, NIST - National Institute of Standards and Technology

Accessibility is a complicated topic with a history of ethical debates about equivalent pedagogical opportunities, resource management limitations, unsolved research questions about perception and cognition, and technical R&D challenges. Other components include interpersonal collaborations and social support systems for those looking to innovate on the field. This presentation is a candid story about two colleagues' efforts to make interactive digital simulations more accessible through the addition of spoken descriptions and sonification. One of the presenters, Keane, has a PhD in physics and is visually impaired. He is steeped in accessibility work through his own personal experience, and has promoted accessibility in science and engineering education at MIT and in partnership with the PhET Project. The other presenter, Gharibnejad, is a traditional physics educator with an interest and commitment to improve STEM accessibility. Together they will discuss how they work together to bridge pedagogy and accessibility without compromising either.

### EE03: 1:30-3:30 p.m. Access to Visual Representations Using 3D-Printed Learning Objects

Invited – Steven Sahyun, University of Wisconsin - Whitewater, 800 W Main St., Whitewater, WI 53190-1319; sahyuns@uww.edu

Particularly for more complicated, multidimensional or time-dependent images, novice learners don't always associate image representations or data in the same manner as those familiar with the material. In addition, information presented or gathered in a visual-only mode is inherently inaccessible to students who are unable to view or have difficulty interpreting what they are seeing. In an effort to create a more inclusive laboratory and classroom environment for students with visual difficulties, a number of objects commonly encountered in physics classes and laboratory settings that can be fabricated with a 3D-printer have been designed. Object files may be downloaded from a Website[1] by a student's instructor and then produced on a local 3D-printer. These tactile objects provide a method for universal design and multi-modal learning in physics instruction and allow representation of an object or concept under discussion that is otherwise only available as pictures. 1. <http://sahyun.net/3dprint>

## Session EF: Introductory Courses II

Location: Marriott Marquis - Tulip Sponsor: AAPT Time: 1:30–3:30 p.m. Date: Tuesday, July 31 President: Stephen Irons

### EF01: 1:30-1:40 p.m. Comparison of Introductory Physics Students' Attitudes and Approaches to Problem Solving with Those of Introductory Astronomy Students Using a Validated Survey

Contributed – Andrew J. Mason, University of Central Arkansas, Lewis Science Center 171, Conway, AR 72035-0001; ajmason@uca.edu

Melanie Good, Chandralekha Singh, University of Pittsburgh

We examined how introductory physics students' attitudes and approaches to problem solving compare to those of introductory astronomy students, using a previously validated survey called the Attitudes and Approaches to Problem Solving (AAPS) survey. In addition, we compared the performance of physics and astronomy students on the factors that were identified in a factor analysis of the validation study. Findings will be presented. We thank the National Science Foundation for support.

### EF02: 1:40-1:50 p.m. Flipped Classes: A Low-Stakes Opportunity for Problem Solving

Contributed – George E. Matthews, Wake Forest University, Dept. of Physics, P.O. Box 7507, Winston Salem, NC 27109; matthews@wfu.edu

Jack A. Dostal, Wake Forest University

Increased class time spent in interactive engagement has been proven valuable in improved student learning. Flipped classes fully embrace this concept by dedicating most teacher-student contact time to activities that engage students in applying concepts of physics to difficult questions and problems. We describe our implementation of flipped classes that pushes nearly all lecture to online videos and uses nearly all class time in small-group problem solving, ConcepTests, and similar activities. In-class activities are NOT graded. Flipped classes present a unique opportunity for extensive problem-solving activities that do not affect course grade. Since rewards have been proven to diminish performance on cognitive tasks, building a place for risk- and reward-free problem solving may contribute to the improved learning observed in our classes. We report improved student learning as measured by the Force Concept Inventory and student perceptions.

### EF03: 1:50-2:00 p.m. The Nature of Introductory Physics Students' Vector Difficulties with Physics Contexts

Contributed – Xian Wu, University of Connecticut, 2152 Hillside Road, Unit 3046, Storrs Mansfield, CT 06269-0001; xian.wu@uconn.edu

Diego Valente, University of Connecticut

Students in introductory physics courses are required to have a reasonably good grasp on basic vector algebra along with conceptual understanding of fundamental physical principles to develop proficiency in problem-solving. The Test of Understanding of Vectors (TUV), as a standard diagnostic test, was built upon previous studies to assess students' understanding on 10 fundamental vector concepts from a mathematical viewpoint. In this study, we have probed how the addition of physics contexts to the items in the TUV affects students' conceptual understanding of vectors. We have randomly assigned our participants to two groups: one taking the original TUV, with the other taking the TUV with physics contexts. Students were asked to show the problem-solving procedure on each item they answered. We qualitatively coded student responses and investigated how adding a layer of physics context to the TUV problems affected student understanding on all ten fundamental vector concepts. This study granted us new insight on the challenges students struggle with when using vectors in introductory physics courses.

**EF04: 2:00-2:10 p.m. "Design Your Own Physics Problem": A New Approach to Introductory Physics Problems**

*Contributed – Barbara L. Whitten, Physics Department, Colorado College, 14 E. Cache la Poudre, Colorado Springs, CO 80903-3294; bwhitten@ColoradoCollege.edu*  
*Steve Getty, Quantitative Reasoning Center, Colorado College*  
*Joe Taylor, Biological Sciences Curriculum Study*  
*Natalie Gosnell, Physics Department, Colorado College*

Solving problems is an important part of physics education; students spend most of their study time working problems, and faculty rely on this practice to help students learn significant concepts and techniques. Recently, we have experimented with a new assignment, in which we asked students to design their own problems. We'll describe the assignment, give examples of student-designed problems, and describe our evaluation of this assignment.

**EF05: 2:10-2:20 p.m. Using Board Games to Understand Physical Concepts**

*Contributed – Matt Olmstead, King's College, 133 North River St., Wilkes Barre, PA 18711; matthewolmstead@kings.edu*

One of the goals of our physics senior seminar class is to both introduce newer ideas of physics while at the same time integrating the students previous knowledge. One idea implemented is to play several games that require looking at physics from a different perspective. The game that will be discussed involves students drawing from selected physics topics while at the same time guessing what the other students are drawing. Specific examples will be discussed including instances where students drew very similar pictures for different clues (constructive interference and resonance), when a student had to draw something that could easily be mistaken for one of the other clues (possible options include gravity, free-fall, Einstein, General Relativity, Newton), and what happens when students don't remember. Trying to distinguish and draw these similar concepts as part of a game requires looking at physics from a different perspective.

**EF06: 2:20-2:30 p.m. Impact of a Math Tutorial on Underrepresented Minority Student Success in Algebra-based Introductory Physics**

*Contributed – Donna Stokes, University of Houston, 617 Science and Research #1, Houston, TX 77204-5005; dstokes@uh.edu*  
*Rebecca Forrest, University of Houston and Data Analytics and Impact at Cradle to Career*  
*Andrea Burrige, University of Houston*  
*Carol Voight, Deer Park Independent School District, Deer Park High School*

A math tutorial intervention was implemented in introductory algebra-based physics courses as a means to increase student odds of passing the course. Of the 643 students enrolled across six sections, 231 were identified as at risk based on a math pre-test score. Chi Square statistical tests showed that underrepresented minority (URM) groups were more likely to be classified as at-risk with African Americans having the greatest risk. A generalized estimating equations (GEE) logistic regression model was used to investigate the likelihood of completing the tutorial and the impact of tutorial completion on the odds of receiving a passing grade (?50%). The analyses showed that underrepresented minority groups were just as likely to complete the tutorial, and that those completing the tutorial were four times more likely to earn a passing final grade; therefore the math tutorial may be used to foster the success of URM groups in introductory physics courses.

**EF07: 2:30-2:40 p.m. The Music of Physics: More Than Equation Hunting**

*Contributed – William G. Nettles, Union University, 1050 Union University Drive, Jackson, TN 38305; bnettles@uu.edu*

Students first learning physics often think that physics problem solving is simply about finding the right equation or that physics is merely mathematical. Our difficulty as teachers is convincing them otherwise. Perhaps using music, which most students enjoy, as an analogy will inspire them to understand and use a more holistic approach to physics. Jazz musician Victor Wooten, in his book, *The Music Lesson*(1), outlines several qualities which are important for the musician to integrate in making music. Inspired by Wooten's book, the presenter explores important aspects of problem solving that work together to help the physicist compose solutions to problems.

(1) *The Music Lesson: A Spiritual Search for Growth Through Music*, Victor Wooten, Penguin Books (2008).

**EF08: 2:40-2:50 p.m. Multiple Choice Questions: Right or Wrong?**

*Contributed – Guillaume M. Laurent, Auburn University, 206 Allison Laboratory, Auburn, AL 36849-5606; glaurent@auburn.edu*

We present a comparative study of performance in Introductory Physics class (PHYSICS 1) between Honors and Non-Honors engineering students. The learning conditions and teaching approach have been kept the same for these two groups of students during the semester (instructor, class size, assignments, exams, grading, ...). As expected, we observed that, in average, the Honors students performed better in all aspects of the class: homework, attendance, quizzes, and exams. The top 50% of the non-honors students have shown the same level of performance as Honors students, though. For these two groups of students, we have measured a clear correlation between both their quiz and test exams grades and their final exam grades. Surprisingly, we have also observed a clear correlation between the students' performance and the evaluation method, indicating that multiple choice questions might not be adequate to evaluate their knowledge and understandings of Introductory Physics.

**EF09: 2:50-3:00 p.m. Mario Kart: A Study in Image Formation and Total Internal Refraction**

*Contributed – Robert D. Polak, Loyola University Chicago, 1032 W Sheridan Rd., Chicago, IL 60660; rpolak@luc.edu*  
*Lana Tinawi, Jonathan Cirone, Matthew Conway, Joseph Summers, Loyola University Chicago*

In Mario Kart 8, characters race through underwater tracks, yet, objects above the water appear to be exactly where they would be – as if the refraction of light passing from water into air did not occur. We present a lesson where we ask students to predict what a racer would see based on the physics they have learned and then assist them through a discovery process using ray tracing. Finally, we demonstrate the principle of refraction and total internal reflection with a submerged GoPro camera. Guided by these steps, we show how underwater images can be used to determine the critical angle of the water-air interface and determine water's index of refraction.

**EF10: 3:00-3:10 p.m. MotivaTED to Learn Good Teamwork?**

*Contributed – Kathleen A. Harper, The Ohio State University, 2070 Neil Ave., Columbus, OH 43210; harper.217@osu.edu*

No matter what profession our students choose, they will need a strong set of professional skills. Teamwork is consistently identified by employers as a particularly important area. Science and engineering courses naturally lend themselves to cooperation, providing an opportunity for students to explore and develop aspects of productive teamwork. As part of a long-term project in a first-year college engineering course, students were given periodic assignments to watch TED talks addressing aspects of teamwork. Each assigned video was accompanied by a short completion quiz to prompt reflection. The resulting reflections were qualitatively analyzed to determine what messages about teamwork the students took away from the experience. These were compared to the expectations of the course's instructional team. Details of the videos and questions will be shared, along with trends in the analysis and implications for future instruction.

**EF11: 3:10-3:20 p.m. Using Google Drive to Achieve Student Cooperation in Large Enrollment Introductory Physics Classes**

*Contributed – Yuhfen Lin, California State University, Chico, 400 West First St., Chico, CA 95929; ylin30@csuchico.edu*

*David T. Brookes, California State University, Chico*

Getting students to be actively engaged in a large enrollment class has many challenges. It is especially important to get the majority of students to come to the class on time and then engage in the group activities instead of getting lost on their phones. In our classes, students submit pictures of their group's whiteboard activities using the Google drive. This allows us to take attendance and share student work without spending extra time or extra equipment. In lab, students use Google docs, to work collaboratively on their group lab report. Using Google docs this way facilitates the process of grading and giving feedback. There is no more passing the papers back and forth. Google drive has allowed us to spend more time focused on student learning and less time dealing with paperwork.

**EF12: 3:20-3:30 p.m. Road Capacity with a Steady Flow of Traffic**

*Contributed – Percy Whiting, Portland Community College, 12000 SW 49th Ave., Portland, OR 97219-7132; percywhiting@gmail.com*

*Leonid Minkin, Portland Community College*

Problems of optimization in natural science, technology, economics, and management are of great interest. Students also usually find them intriguing. However, the selection of such problems in undergraduate physics textbooks is very limited and should be broadened. To that end, a model of traffic flow optimization, simple enough for undergraduates to analyze, is presented here. This problem, which students can easily relate to their everyday experience, will acquaint them with concepts useful in hydrodynamics, electrostatics, and electric current models.

**Session EG: Learning Assistants' Role in Affecting Community in Physics Departments and Beyond**

**Location:** Congressional Ballroom B **Sponsor:** Committee on Research in Physics Education **Co-Sponsor:** Committee on Physics in Undergraduate Education

**Time:** 1:30–3:30 p.m. **Date:** Tuesday, July 31 **President:** Gary White

**EG01: 1:30-2:00 p.m. LA Program Infrastructure to Support Institutional Change**

*Invited – Laurie Langdon, \* University of Colorado Boulder, UCB 249, Boulder, CO 80304-1425; laurie.langdon@colorado.edu*

The Learning Assistant model catalyzes change not by pushing specific reforms or trying to change faculty directly. Instead, it offers resources and structures that lead to changes in values and practices among faculty, departments, students, and the institution. In this presentation, I will highlight three structures that facilitate change at CU Boulder. Departmental Coordinators (DCs) serve as liaisons between the Program and their departments; they meet to discuss strategies for engaging and educating faculty and to review faculty course proposals. LA Central software supports the overall operation of the program, including functionality that allows DCs to monitor and provide feedback to faculty applying to use LAs in their courses. The LA Mentoring Program engages experienced LAs as LA Mentors for first-time LAs. They observe settings in which LAs are used, consult with their mentee and faculty member throughout the semester, and serve as liaisons to the LA Program.

\*Sponsored by Gary White

**EG02: 2:00-2:30 p.m. Talking about Teaching, LAs Insert Themselves into the Conversation**

*Invited – Mark Reeves, George Washington University, Department Of Physics, 725 21st St NW, Washington, DC 20052-0001; reevesme@gwu.edu*

*Tiffany-Rose Sikorski, George Washington University*

At GW, we have a Learning Assistant program that adheres closely to the Colorado Model that is described on the LA Alliance website. Two very important aspects that are driving our department's transformation are 1) the person-power of having one LA for every 15 students to enable teaching classes with close to 60% of their time dedicated to student-centered learning, and 2) a community of LAs that talk: to each other, to the students, to their instructor, to the departmental coordinator, to the instructor leading the pedagogy class. These conversations provide up and down linkages from students to instructors as well as instigate horizontal discussions between students and between instructors teaching across the introductory curriculum in our physics department. In my talk, I will focus on my experiences as an instructor and as a departmental coordinator to describe how LAs have reformed my own teaching and the teaching in my department.

**EG03: 2:30-3:00 p.m. A Cultural Analysis: An LA Program's Life, Death, and Reincarnation\***

*Invited – Chandra A. Turpen, University of Maryland, College Park, 6701 Adelphi Rd., University Park, MD 20782; chandra.turpen@colorado.edu*

*Ayush Gupta, University of Maryland, College Park*

In this talk, we describe the meaningful shifts in institutional routines that emerged during the six-year lifespan of the Maryland LA Program (e.g. new learning experiences for students enrolled in LA-supported courses, pedagogical growth for faculty, and examples of LAs' activism within the university and broader community). These accounts suggest glimmers of cultural change. However, we also describe the death of the science-focused LA program at University of Maryland, as the "factory model" of higher education co-opted this program for its own purposes. We reflect on how our LA program was more effective at contesting problematic cultural assumptions with our LAs than with university administrators and faculty. We describe the specific institutional challenges that were present for our science-based LA program, and suggest some key differences that have allowed our Maryland LA program to re-emerge within the College of Engineering.

\*Work supported by NSF#0831970 & NSF#1733649

**EG04: 3:00-3:30 p.m. Creating Resilient Community Through the TXST Learning Assistant Experience\***

Invited – Eleanor W. Close, Texas State University, 601 University Dr., San Marcos, TX 78666-4615; [eclose@txstate.edu](mailto:eclose@txstate.edu)

Jessica Conn, Shahrzad Hesaaraki, Ryan J. Zamora, Texas State University

The Physics LA program at Texas State is structured to support development of collaborative relationships among participants, including faculty, LAs, and students. The departmental decision to implement LA support in all sections of the calculus-based introductory physics sequence has created a community of learners with a large body of shared experiences of research-based instructional strategies, both as students and as facilitators of instruction. The majority of our majors now serve as LAs for at least one semester. In interviews and written reflections, LAs describe changing their ways of learning and of being students, both within and beyond physics, as a result of their LA experience. In addition, they perceive themselves to have increased competence in communication and a stronger sense of belonging to a supportive and collaborative community of peers, near-peers, and faculty. We analyze the LA experience in terms of Communities of Practice and negotiation of identity.

\*Supported by NSF DUE-1557405, DUE-1431578, and PHY-0808790

**Session EH: PER: Diversity, Equity & Inclusion**

**Location:** Mount Vernon Square B **Sponsor:** AAPT/PER **Time:** 1:30–3:20 p.m. **Date:** Tuesday, July 31 **President:** Angela Little

**EH01: 1:30-1:40 p.m. Centering Women of Color in Physics: Rethinking Family and Identity**

Contributed – Apriel K. Hodari,\* Queen Mary, University of London, 1702 Shepherd St. NW, Washington, DC 20011-5356; [a.hodari@qmul.ac.uk](mailto:a.hodari@qmul.ac.uk)

Angela C. Johnson, Elizabeth A. Mulvey, Rose Young, St. Mary's College of Maryland

Vanessa S. Webb, Northern Virginia Community College

Centering marginalized voices has long been a tool for critiquing predominantly white institutions and individual practices by feminist theorists and critical race scholars. In this paper, we ask, “To what degree are physics departments that have proven to be inclusive of women of color also inclusive of other marginalized populations?” My examining the lives of students who parent and students of transgender experience, we seek to broaden traditional notions of diversity by breaking open who we see as belonging in physics learning spaces. The students who have shared their experiences with us offer new insights in the classroom cultures physics educators are co-creating with them. The ultimate goal of this work is to provide insights into how physics spaces that were not created for marginalized populations (women of color, students who parent, students of trans experience) can become more welcoming of them, and thereby increase thriving for all students.

\*Sponsored by Angela C. Johnson

**EH02: 1:40-1:50 p.m. Intersectional Physics Identity Framework**

Contributed – Angela Johnson, St. Mary's College of Maryland, Goodpaster Hall, Saint Marys City, MD 20686-3001; [acjohnson@smcm.edu](mailto:acjohnson@smcm.edu)

For the past several years, I have been studying a physics department where women of color feel successful and like they belong (typical comment: “physics is what I’ve always been interested in. It doesn’t feel like I’m out of place. It’s the subject I’m interested in.”) In this presentation, I will present the physics identity which is available in this setting, and how that identity is accessible to women of color. I conceptualize identity not as an internal individual experience but as a feature of a social setting. I will also describe the approach I used to derive this identity (based on Patricia Hill Collins’ Domains-of-Power Framework), an approach that would be useful to other scholars interested in either physics identity or issues of diversity in physics.

**EH03: 1:50-2:00 p.m. The Intersection of Identity and Performing Arts of Black Physicists**

Contributed – Tamia Williams, Mount Holyoke College, 2743 Throop Ave., Bronx, NY 10469; [willi26t@mtholyoke.edu](mailto:willi26t@mtholyoke.edu)

Simone Hyater-Adams, Noah Finkelstein, University of Colorado Boulder

Claudia Fracchiolla, University College Dublin.

Kerstin Nordstrom, Mount Holyoke College

Kathleen Hinko, Michigan State University

How one negotiates their physics identity is crucial to gaining and maintaining membership in the physics community (Wenger, 2010). However, there is an exclusive culture of physics that has marginalized Black people and leads them to feel that they do not fit the criteria of who a physicist is supposed to be (McGee, 2016). Therefore, to understand what keeps Black physicists in the field, we must analyze their physics experiences. Studies show that the arts can act as an identity mediator or coping mechanism for underrepresented groups in STEM (Mejia, 2012). In this work, we collect and analyze interviews of 13 Black physicists, building on previous studies. We find themes in the ways that Black physicists participate in the performing arts. We map those themes onto the previously developed Critical Physics Identity framework (Hyater-Adams et al., 2017) in order to understand how the arts have impacted their physics identities.

**EH04: 2:00-2:10 p.m. Characterization of Success in Physics from a Feminist Standpoint**

Contributed – Brian Zamarripa Roman, University of Central Florida, 4111 Libra Drive, Orlando, FL 32816; [b.zamarripa@knights.ucf.edu](mailto:b.zamarripa@knights.ucf.edu)

Jacquelyn J. Chini, University of Central Florida

Representation of women in physics has increased significantly since the 1960s; however this increase has plateaued at 20% of bachelor’s degrees awarded to women yearly, while other STEM fields, such as chemistry and biology, have reached gender parity. For this reason, physics education researchers have focused their efforts on developing strategies to attract, retain, and increase the number of successful women physicists. Although research to promote the “success” of women is common, what success “is” has gone severely unexplored and likely varies based on the researchers’ (often implicit) perceptions of success. This qualitative study is guided by Feminist Standpoint Theory to develop our understanding of success from the standpoint of women, who are traditionally marginalized in physics. We explore characteristics of success through semi-structured interviews of women in different stages of their physics career, including undergraduate and graduate students, and present emergent themes from their responses.



**EH05: 2:10-2:20 p.m. How Physics Students Learn, Adapt, and Defy Unspoken Cultural Expectations**

Contributed – Mary K. Chessey, University of California, Davis, One Shields Ave., Davis, CA 95616; mkchessey@ucdavis.edu

David J. Webb, University of California, Davis

Many physics students hold the belief that a career in physics is not intended for people like them, but use characteristics of stubbornness and passion for the subject to defy expectations. Factors such as age, employment, parenting, commuting, national origin, ethnicity, gender, and family background influence students' behavior in academic physics settings, which reveals a set of implicit cultural expectations for undergraduate physics majors in a large research university. During a 15-month period of observation of upper division physics transfer students, study participants adapted to the unfamiliar environment and cultivated an active community focused on inclusion. The discussions and activities within this community highlight the elements of traditional lecture-based physics education that isolate and discourage students. At the same time, students make a livable working environment for themselves using strategies of resistance and mutual support. Patterns and complexities in transfer student progress through an undergraduate physics degree are reported.

**EH06: 2:20-2:30 p.m. A Synthesis of the Gender Gap on the Conceptual Inventories**

Contributed – Rachel Henderson, West Virginia University, 392 Dorsey Ave., Morgantown, WV 26501 rjhenderson127@gmail.com

John Stewart, West Virginia University

Adrienne Traxler, Wright State University

Recently, research has shown that the Force Concept Inventory (FCI) contains 11 items that show gender bias and eliminating these items reduces the overall gender gap by 50% in some samples. The study was extended to the Force and Motion Conceptual Evaluation (FMCE) and the Conceptual Survey of Electricity and Magnetism (CSEM); however, the number of items identified in the FMCE and the CSEM were substantially smaller than the number of items identified in the FCI. The current work will explore the overall gender gap in each of the conceptual inventories for male and female students of equal incoming physics knowledge measured by a "valid" pretest score. In addition, this work will suggest that the overall gender gap can be separated into a "real" gender gap and a gap coming from preparation differences in the student population. Results will be reported for the FCI, the FMCE, and the CSEM.

**EH07: 2:30-2:40 p.m. A Curriculum to Address Under-Representation and Culture in Physics**

Contributed – Moses Rifkin, University Prep, 8000 25th Ave NE, Seattle, WA 98115; mrefkin@universityprep.org

Chris Gosling, McGill University

Dana Hsi

Motivated by our shared desire to address under-representation in physics, we have created a flexible, modular curriculum designed to help physics teachers bring conversations about science and society into our classrooms. In this session, we will preview the curriculum, share preliminary data demonstrating its influence, and reflect on our experiences. Attendees will have an opportunity to download curricular resources, and will learn how to join our working group going forward. Together, we offer students and teachers a guided means to consider the culture of physics in order to create a more welcoming community.

**EH08: 2:40-2:50 p.m. Let's Talk About Equity – Two-Year College Students and Physics Culture**

Contributed – Abigail R. Daane, South Seattle College, 6000 16th Ave SW, Seattle, WA 98106; abigail.daane@gmail.com

Elizabeth A. Schoene, South Seattle College

We taught a week-long equity unit in an introductory calculus-based physics course, focusing on the effects of race and culture on the physics community. The demographics of these two-year college courses look vastly different than those of the physics field; students of color outnumber white students. Given this reversal of representation, our aim was to increase awareness of the racial inequity that is present in the rest of the physics community and to facilitate the development of support systems to move forward in STEM careers. We collected and analyzed written student reflections from these classes to better understand the views students of color bring to the equity conversation. We identified themes in their ideas about equity in physics and we argue that their responses indicate a need for explicit discussions in physics classrooms and the greater community.

**EH09: 2:50-3:00 p.m. Culture and Ideology in How LAs "See" (In)equity in Student Groups\***

Contributed – Ayush Gupta, University of Maryland, College Park, 3535 Duke St., College Park, MD 20740; ayush@umd.edu

Chandra Turpen, Jennifer Radoff, Andrew Elby, Hannah Sabo, University of Maryland, College Park

Learning Assistant (LA) programs have emerged within PER as an effective model for curriculum and cultural transformation in undergraduate learning environments. At UMD, adapting from the CU-Boulder model, we have started an LA program with two novel and interlinked foci: (1) The LAs all mentor teams of engineering students doing long-term projects in a first-year engineering design course, and (2) we scaffold the LAs in fostering equitable team dynamics and collaboration within the introductory engineering design course. In this talk, we analyze LAs' (i) interpretations of teamwork troubles, (ii) instructional responses, and (iii) role-playing to simulate problematic interpersonal dynamics and responsive instructional moves. We show that LAs' actions and responses more frequently embodied ideological assumptions foregrounding individual merit and responsibility, treating individuals as autonomous agents divorced from their settings, and backgrounding relational dynamics and systems-based analysis of teamwork troubles. These assumptions tie in with aspects of broader STEM culture such as meritocracy and social-technical dualism. These observations help us identify gaps in the design of the pedagogy seminar that we hope to address in future iterations.

\*Work supported by NSF Grant 1733649.

**EH10: 3:00-3:10 p.m. Shifting Power Dynamics in STEM Instruction by Leveraging the Learning Assistant Model\***

Contributed– Mel Sabella, Chicago State University, Chemistry, Physics, and Engineering Studies, Chicago, IL 60628; msabella@csu.edu

Andrea G. Van Duzor, Felicia Davemport, Fidel Amezcua, Dontrell Cornelius, Chicago State University

The Learning Assistant (LA) Model involves undergraduate students as peer support in STEM classrooms. LAs meet weekly with the instructors in whose classes they serve. Although there are a number of models of interaction between LAs and instructors, there is the potential for LAs to take up power and responsibility in these relationships. In this talk we provide examples of how LAs can be invited more intentionally as collaborators where they are integral participants in instructional design. We show that involvement in this collaborative relationships with faculty is important to LAs in feeling like valued members, rather than guests, in learning and teaching communities. We draw on the framework of "rightful presence" (Calabrese-Barton & Tan, 2017), used to understand equity-oriented teaching, as a use-

ful lens in analyzing collaborative partnerships in the LA Model. Barton, A. C., & Tan, E. (2017). Designing for rightful presence in STEM-rich making: Community ethnography as pedagogy.

\* Supported by the National Science Foundation (DUE#1524829) and the Department of Education

1. Barton, A. C., & Tan, E. (2017). Designing for rightful presence in STEM-rich making: Community ethnography as pedagogy.

### **EH11: 3:10-3:20 p.m. Increasing Visibility to Increase Diversity in Physics Graduate Programs\***

*Contributed – Lindsay Owens, Rochester Institute of Technology, 85 Lomb Memorial Drive, 3355 Gosnell Hall, West Henrietta, NY 14586-8839; Imosch@rit.edu  
Benjamin Zwickl, Scott Franklin, Casey Miller, Rochester Institute of Technology*

Positive steps towards increasing diversity are rising among the physics community with many departments transforming their practices to become more holistic and inclusive. In this multiple case study, we interviewed both faculty and graduate students in three physics and astronomy departments regarding the admission of students into graduate physics programs. Each of the three programs varied in their geographic location. One institution was a large public university while the other two were smaller not-for-profit institutions. Despite these differences, there was a common goal to increase the diversity of students in their programs as well as a shared concern regarding the lack of diversity in the applicant pool, inevitably blocking the road to a more diverse cohort of admitted students. Solutions proposed were unique to each program and ranged from increasing visibility through online media, targeted recruitment through neighboring institutions, and affiliating with the APS Bridge Program.

\*Supported by NSF-1633275.

### **Session EI: Panel – Professional Skills for Graduate Students**

**Location:** Meeting Room 2    **Sponsor:** Committee on Graduate Education in Physics    **Co-Sponsor:** Committee on Research in Physics Education

**Time:** 1:30–3:30 p.m.    **Date:** Tuesday, July 31    **Presenter:** Lisa Goodhew

*This interactive panel focuses on developing professional skills for graduate students and other early-stage researchers. This session will address professional concerns brought up by graduate students during the past Graduate Student Topical Discussions. Topics covered may include: preparing for careers after graduate school, becoming integrated with the community, developing research skills, and disseminating your work. While this session is aimed toward graduate students, we welcome undergraduates who are interested in this professional development opportunity or curious about life as a graduate student!*

#### **Speakers:**

*Jayson Nissen, Cal State - Chico*

*Gina Quan, University of Colorado*

*Benjamin Pollard, University of Colorado*

*Anne Leak, Rochester of Technology*

### **Session EJ: PTRA: Integration of Literature in K-6 Science**

**Location:** Meeting Room 3    **Sponsor:** Committee on Physics in Pre-High School Education    **Time:** 1:30–3:30 p.m.    **Date:** Tuesday, July 31

**Presenter:** Katya Denisova

### **EJ01: 1:30-2:00 p.m. PTRA Integration of Literature in K-6 Science**

*Invited – William Reitz, 2921 Kent Rd., Silver Lake, OH 44224; wreitz@neo.rr.com*

This miniature workshop will engage participants in cross-disciplinary hands-on physics explorations based on elementary children's literature. We will demonstrate how to use picture books, fairy tales, and elementary poetry to get young learners excited about asking authentic questions and doing 'real' physics. We will also share our collection of children's books with direct connections to classical physics content. The session may be of interest to anyone who wants to make Physics instruction more engaging, meaningful, and fun to students of all ages!"

**EK01: 1:30-1:40 p.m. The Effects of the Length of Junctions Between Balls**

Contributed – Hao Xin Sun, No.2 Dongnandaxue Road, Nanjing, Jiangning 211100 958664094@qq.com

If a chain initially rests in a container above the ground and pulled over the rim of the container, the top of the chain will rise up above the container, which is called a “chain fountain.” Since researchers did not include the effects of junctions between balls, former models fail to predict the experimental results when using chains with balls in different shapes. In our experiments, the relation between the steady-state chain height and the length of junctions of the chain is analyzed experimentally and theoretically. Data is collected by using chains with junctions of different lengths while their other physical parameters are constant during experiments. Meanwhile, the weight of junctions is relatively small compared with the whole chain, so its impact is neglected during our analysis. We map the Height-Length of Junctions diagram and the measurements for different chains coincide with our theoretical analysis.

**EK02: 1:40-1:50 p.m. Further Research on the Spring Pendulum**

Contributed – Yan Huang, Southeast University, No.2 Dongnandaxue Road, Jiangning District, Nanjing, China 210000 China wxhuangy@sina.cn

Hua Yuan, Ze Hua Tang, Southeast University

When a pivot of a spring pendulum starts moving along a horizontal circumference, the movements of the bob attached to the spring exhibit different patterns. Difference method is used to do theoretical analysis concerning length and movement of the spring, and numerical results correspond with that. In the low angular velocity regime, the dynamic system of the spring pendulum shows various bifurcations. When the stiffness coefficient becomes larger than a certain degree, the system turns into chaos.

**EK03: 1:50-2:00 p.m. Nonlinear Analysis of a Popsicle Stick Bomb**

Contributed – Chengzhi Cai, No.2 Dongnandaxue Road Jiangning District Nanjing, jiangning 211100 China 970489129@qq.com

A large potential energy can be released when weaving the stick bomb. However, in the experiment of the popsicle stick bomb, we find that repetitive experiments lead to a great uncertainty in measurement. It is because that when stress exceeds the threshold, popsicle sticks experience yield phenomenon which means plastic deformation and disability of returning to the original state. In this case the pattern of stress and strain is a nonlinear function. The experiment explores the law of nonlinear variation in the popsicle stick bomb. The experimental data is measured by using popsicle sticks with different sizes and different materials. Meanwhile, we use the same group of sticks in a series of experiments. The deformations of the sticks ranges from big values to small values. We also map the Stress-Strain diagram. Finally, we get the range of linear variation and the rule of nonlinear variation. Materials also impact results.

**EK04: 2:00-2:10 p.m. Explanation of Rotation Mechanism of Liquid Film Motor Via Ions**

Contributed – Hongzhi Zhu, No.2 Dongnandaxue Road Jiangning District Nanjing, Jiangning 211102 China zhzzhz990323@126.com

We present a qualitative explanation of the rotation mechanism of the liquid film motor via movement of ions. Principle of electrolytic cell is introduced into our model, in which the essence of the crossing current in liquid is the directional movement of ions and as soon as an ion has reached the electrode, electrons are exchanged so that the ion loses its charges. Several quantitative analytic results involving the speed of rotation and the threshold voltage of the crossing current are obtained. We find that the interaction of the electrolytic cell and the polarization equilibrium maintained by the external electric field causes stable one-way flows in two sides along the electric field in adverse directions. The flows of ions lead to the rotation of the whole film. Though traditional theories via polarization of molecules can both explain the holistic rotation, Our theory can perfectly explain the local flow in high concentration film which could hardly be explained by traditional theories, and most experimental phenomena observed in direct current electric fields are interpreted well.

**EK05: 2:10-2:20 p.m. The Electrobrachistochrone**

Contributed – Carl E. Mungan, United States Naval Academy, Physics Mailstop 9c, Annapolis, MD 21402-1363; mungan@usna.edu

Trevor C. Lipscombe, Catholic University of America Press

The brachistochrone problem consists of finding the track of shortest travel time between given initial and final points for a particle sliding frictionlessly along it under the action of gravity alone. Solvable variations of this standard example would be interesting as homework and computer projects by undergraduate physics students. An electrobrachistochrone problem is presented in this talk, in which a charged particle moves under the influence of its electrostatic force of attraction to an image charge in a grounded conducting plane located below the track (but ignoring gravity). The path of least time is found to be a foreshortened cycloid and its properties are investigated analytically and graphically. This problem bridges the fields of intermediate mechanics and electromagnetism which are typically studied concurrently by physics majors in their junior year.

Eur. J. Phys. <https://doi.org/10.1088/1361-6404/aaadf0>

**EK06: 2:20-2:30 p.m. Physics for Engineering Students: PV Course Case Study**

Contributed – Adel B. Gougam, Khalifa University of Science and Technology, bldg1A Masdar City, Abu Dhabi, UAE 54224 UAE adel.gougam@gmail.com; agougam@masdar.ac.ae

This paper addresses the case study of using a photovoltaic (PV) course teaching example to introduce various physics concepts to undergraduate engineering students. A Holistic approach whereby optical, electrical phenomena as well chemical processes are taught with increasing difficulty as the course progresses in the context of explaining how a photovoltaic device operates and how the various aspects are correlated to allow for performance improvement of the PV device. The approach being multidisciplinary (mainly physics with chemistry, materials science, electrical engineering notions) allows for an enhanced interest from students, considering they have different backgrounds and rather theoretical understandings of the many physics concepts taught in previous courses in their curriculum. Re-introducing the many physics concepts they may have learned previously and newer ones in this context of a PV system operation seems to allow for a seamless enhancement of the student's ability to absorb the new and sometimes difficult concepts.

**EK07: 2:30-2:40 p.m. Meaningful Experiences in a Modern Physics Laboratory Course**

Contributed – Helen M. Cothrel, Eastern Michigan University, 2356 McKivett Dr., Toledo, OH 43615; helen.cothrel@gmail.com

Jonathan Skuza, Eastern Michigan University

Modern physics is a crucial course due to its context as a bridge between the introductory level and quantum mechanics. Laboratory courses in modern physics are under scrutiny due to a dearth of evidence that their benefits to students—especially regarding content knowledge—outweigh the resources needed to maintain them. As such, it is worth questioning whether it is justifiable to continue to offer labs along with lecture in modern. This study examines students' experiences in a modern physics lab through beginning- and end-of-semester interviews to learn what is meaningful or valuable (or not) to them about the lab. I will present the results of one student's interviews as an example case to show that students' ideas about the modern physics lab extend beyond content knowledge.

**EK08: 2:40-2:50 p.m. Visualization of Nelson's Approach of Quantum Mechanics Using Microsoft EXCEL®**

Contributed – Shinil Cho, La Roche College, 9000 Babcock Blvd., Pittsburgh, PA 15101-1707; shinil.cho@laroche.edu

The quantum mechanical motion of electrons can be visualized by applying the Nelson's Newtonian like equation. In this paper, after introducing the Nelson's approach, we demonstrate the electron orbits. As Excel can perform iteration calculation without programming, displaying electron motions in various potentials on screen is a good hands-on project of quantum mechanical project. We show several result of electrons in the Coulomb potential and the harmonic oscillation along with other electron motions.

**EK09: 2:50-3:00 p.m. Developing Robust Clicker Question Sequences for Quantum Mechanics**

Contributed – Paul D. Justice, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; paj42@pitt.edu

Emily Marshman, Chandralekha Singh, University of Pittsburgh

Effective use of clicker questions in physics courses at all levels and in classes of all sizes can be an excellent formative assessment tool and can help students learn physics and develop their reasoning and meta-cognitive skills. Here we discuss our research on the development and evaluation of effective clicker question sequences for helping students learn quantum mechanics. We discuss the effectiveness of implementing validated clicker question sequences in a quantum mechanics course.

**EK10: 3:00-3:10 p.m. Helping Students Learn to Count the Number of Many Particle States with a Fixed Number of Available Single-Particle States for a System of Identical Particles**

Contributed – Christof K. Keebaugh, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260-3583; ckk10@pitt.edu

Marshman Emily, Chandralekha Singh, University of Pittsburgh

We discuss an investigation of student difficulties with counting the number of distinct many-particle stationary states for a system of non-interacting identical particles for the case in which the energy of the system is not constant but there are a fixed number of available single-particle states for the particles. The investigation was carried out in advanced quantum mechanics courses by administering free-response and multiple-choice questions and conducting individual interviews with students. We discuss the common student difficulties related to these concepts. These findings are being used as a guide for creating learning tools to help students develop a functional understanding of concepts involving counting the number of distinct many-particle stationary states for a system of non-interacting identical particles.

**EK11: 3:10-3:20 p.m. A Study of Midwestern Graduate Physics Programs: Early Stages**

Contributed – Christopher Porter, The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; porter.284@osu.edu

Andrew F. Heckler, The Ohio State University

In recent years, significant attention has been paid to certain aspects of graduate physics programs, such as admissions practices. Less attention has been paid to the graduate student experience within physics programs. Physics education researchers at the Ohio State University are in the early stages of a study of four Midwestern graduate physics programs. The goals of this study include quantifying characteristics of core courses at each institution and similarly characterizing the candidacy requirements. We examine the nature of instruction and material covered. Additionally, the study focuses on attitudinal and motivational factors that have been linked to student retention at the undergraduate level. Surveys have been constructed through slight modifications of validated metrics to make the wording more appropriate for graduate students in physics. Data have been collected from all four institutions. As this study is in its early stages, only a cross-section of attitudinal and motivational factors can be shown at this time.

**Session EL: Assessment in Physics Teacher Preparation**

**Location:** Marriott Marquis - Scarlett Oak **Sponsor:** Committee on Teacher Preparation **Co-Sponsor:** Committee on Research in Physics Education

**Time:** 1:30–3:40 p.m. **Date:** Tuesday, July 31 **President:** Hunter Close

**EL01: 1:30-2:00 p.m. The Physics Teacher Education Program Analysis (PTEPA) Rubric: Development and Insights**

Invited – Stephanie V. Chasteen, Chasteen Educational Consulting, 247 Regal St., Louisville, CO 80027; stephanie.chasteen@colorado.edu

Rachel E. Scherr, Scherr & Associates

Jessica Alzen, University of Colorado Boulder

Monica Plisch, American Physical Society

The Physics Teacher Education Program Analysis (PTEPA) Rubric(1) is a new instrument designed by PhysTEC to provide a specific, objective, and reliable guide for physics teacher education programs — enabling self-reflection, measurement of program growth, and creating research opportunities. The PTEPA Rubric was developed to describe what “thriving” physics teacher education programs do (i.e., programs at large universities that typically graduate five or more highly-qualified physics teachers in a year). The PTEPA Rubric is informed by the PhysTEC Key Components(2), but offers more specific guidance about program practices and measurement of success. We will describe the process of PTEPA Rubric development, initial insights gained from the instrument, and future research.

We acknowledge funding from NSF-0808790, NSF-1707990 and APS's 21st Century Campaign for development of the PTEPA Rubric.

1 - See <http://phystech.org/THRIVING> for a copy of the rubric and report (released July 2018). 2 - <https://www.phystec.org/keycomponents/>

**EL02: 2:00-2:30 p.m. National Report Card on Physics Teacher Education**

*Invited – Monica Plisch, American Physical Society, One Physics Ellipse, College Park, MD 20740; plisch@aps.org*

*Megan McRae, Virginia Tech*

*Renee Michelle, Goertzen APS*

There is a severe national shortage of qualified high school physics teachers; a major contributing factor is that colleges and universities are failing to prepare sufficient numbers of new physics teachers. The National Report Card on Physics Teacher Education reports the number of new physics teachers educated by colleges and universities, based on an analysis of the U.S. Department of Education Title II data set. We found that over 70% of secondary education programs produced zero teachers with a physics or physics education degree in a recent three-year period. There are also a number of institutions of higher education that prepare substantial numbers of physics teachers, and these colleges and universities are recognized on an “honor roll” of the top 100 physics teacher educators. A state-by-state analysis found that nearly all states prepare less than 40% of the estimated number of new physics teachers needed to replace those who retire or leave the profession. An analysis by institution benchmarks the physics teacher education program relative to state and national averages. The National Report Card is a product of the Physics Teacher Education Coalition (PhysTEC), a project of the American Physical Society and the American Association of Physics Teachers, supported by the National Science Foundation under grant number 1707990.

**EL03: 2:30-2:40 p.m. Study of Development of Reflective Skills as Productive Teaching Habits**

*Contributed – Marianne Vanier, Rutgers University, 10 Seminary Place, New Brunswick, NJ 08901-1267; mmdvanier@gmail.com*

*Eugenia Etkina, Rutgers University*

While the Next Generation Science Standards (NGSS) provide examples of science practices around which educators should center their teaching, little guidance is provided to help structure their implementation in the classroom. We report on the study that examines how pre-service physics teachers (PPTs) develop the skills necessary to center their teaching on science practices through the use of the Investigative Science Learning Environment (ISLE) framework. PPTs at Rutgers University teach laboratories and recitations in an ISLE-reformed introductory physics course as part of their teacher preparation program. This additional teaching experience is coupled with weekly reflections on a Google group page. The development of a coding scheme and an analysis of the reflections behold how the reflections of PPTs show their awareness of the role that science practices play in learning physics.

**EL04: 2:40-2:50 p.m. Assessing Practice and Experiment Design Using a Structured Laboratory Practical**

*Contributed – James Christopher Moore, University of Nebraska Omaha, 6001 Dodge St., Omaha, NE 68182; jcmoore@unomaha.edu*

Within the practice of science, the dimensions of content knowledge, science practice, and reasoning are linked. For example, the Next Generation Science Standards (NGSS) explicitly recognizes this link, where students demonstrate understanding of a topic by showing they can practice science within that domain. This shift in science standards prompts the following question: how do you assess practices? In this talk, I will describe how we have used a structured scientific abilities rubric in combination with laboratory practical exams to assess experiment design. The rubrics used were developed by the Investigative Science Learning Environment (ISLE) project, and were utilized to assess middle-grades pre-service teachers' growth as science practitioners through the incorporation of experiments into summative assessments. I will describe two science practicums, one on periodic motion and the other on spring force, and discuss what indicators we looked for in student work.

**EL05: 2:50-3:00 p.m. When District-Level Teacher Evaluation and Support Structures Deter NGSS Implementation**

*Contributed – William E. Lindsay, University of Colorado - Boulder, 2306 N Franklin St., Denver, CO 80205; william.lindsay@colorado.edu*

*Julian Stenzel Martins, Valerie Otero, University of Colorado Boulder*

The Next Generation Science Standards (NGSS) have potential to impact the way physics is taught and learned in high schools. To ensure successful implementation of the NGSS, districts, school leaders, and researchers need to provide structural supports for physics teachers attempting to reform their pedagogy. Through a long-term Research Practice Partnership with a STEM-focused charter network, physics education researchers collaborated with key district stakeholders to revise structures and resources, such as standards, curriculum, and professional development, that are intended to direct and assess instruction. To make claims about the effectiveness of this strategy, we used a mixed-methods case study employing institutional change theory as an analytical framework. Specifically, we gathered evidence of regulative, normative, and cognitive indicators of change. Our findings suggest that attending to coherence between district instructional guidance infrastructures and reform pedagogy may be a successful strategy for school districts attempting to implement NGSS-aligned physics instruction.

**EL06: 3:00-3:10 p.m. ASELL Schools: Practice of Science and Inquiry through Professional Development**

*Contributed – Manjula D. Sharma, The University of Sydney, School of Physics, Camperdown NSW, NSW 2006 Australia m.sharma@physics.usyd.edu.au*

*Cornish Scott, Vicky Tzioumis, Petr Lebedev, Srividya Kota, The University of Sydney*

Practice of Science and Inquiry, if implemented adequately can transform classrooms into places of wonder, inspiring students to be creative and critical. Yet, despite substantive funding for such endeavors, the transformation in science education has been sluggish. This paper describes ASELL Schools, a professional development program aimed at embedding inquiry approaches across Australian secondary schools in a unique model in which students and teachers work together, with students having increased responsibility for learning. Our results demonstrate that teachers are changing their practices, implementing more inquiry approaches with some resulting in whole school changes.

**EL07: 3:10-3:20 p.m. Investigating Pre-Service Physics Teachers' Views about Physics Representations**

*Contributed – Judyanto Sirait, School of Education, University of Leicester, 48-50 Churchill St., Leicester, O LE2 1FH UK judyantossirait@gmail.com*

*Janet Ainley, School of Education, University of Leicester*

*Martin Bartstow, Department of Physics and Astronomy, University of Leicester*

The ability to represent physics concepts in various forms is a very important skill in physics learning. Therefore, instructors have developed creative approaches by involving representations in the teaching process as a means of enhancing students' understanding. Most previous studies focused on drawing and using representations to help students in learning physics concepts and solving problems. This paper presents a study (qualitative survey) concerning pre-service physics teachers' views about physics representations during problem-solving processes. Interviews have also been conducted to investigate pre-service physics teachers' views about representations in more detail. Semi-structure interviews were used to explore deeply students' motivation to draw or not to draw representation such as free-body diagrams (FBDs) while solving physics problems. We found that most students agree that drawing representations such as picture or sketch, graphs, diagrams aids them to understand physics concepts, physics problems and to find the best solution.

**EL08: 3:20-3:30 p.m. Pre-service Teachers' Physics Conceptual Understanding and Technology Self-Efficacy: Effects of Exploring Physics Curriculum**

*Contributed – Deepika Menon, 8000 York Road, Smith Hall, Physics, Astronomy & Geosciences, Towson, MD 21252; dmenon@towson.edu  
Matthew Conway, Towson University*

*Meera Chandrasekhar, Dorina Kosztin, University of Missouri – Columbia*

The purpose of this study is to investigate the impact of an innovative iPad-based curriculum app, Exploring Physics, on pre-service elementary teachers' physics conceptual understandings and technology self-efficacy during a semester-long specialized physics content course. Participants included 73 pre-service elementary teachers who participated in pre-post implementation of a physics conceptual test and technology self-efficacy survey and open-ended questionnaires. Data analyses included repeated measures analysis of variance and open-coding techniques. Results showed significant positive changes in participants' physics conceptual understandings and technology self-efficacy. Qualitative trends revealed that learning science via curriculum app benefitted participants as learners of science as well as teachers of science. Participants found continuous engagement via iPads throughout the semester enhanced their knowledge of physics concepts as well as exposed them to successful models of the appropriate uses of mobile technologies in classrooms. Findings have implications for pre-service teacher preparation in physics via the use of mobile technologies.

**EL09: 3:30-3:40 p.m. Action Hero Goes on the Road**

*Contributed – John R. Banks, 308 New Manssdale Rd., Madison, MS 39110; jbk54@gmail.com*

Over the last 10 years, I have developed an action hero, Super B (Banks). I have a costume, cape, and flashing wand that dispels ignorance. As the action hero I do interactive science shows with giant bubbles, a bed of nails, elephant toothpaste, human polymers, ruler breaks, exploding pumpkins, fire in the hands, and much more. With this as a springboard I do classroom labs and professional developments with teachers. I have developed a webpage with lessons aligned with Next Generation Science Standards with each of my show's interactive hands-on, minds-on demonstrations.

**Session EM(A): Articulations and Transfer between Two Year Colleges and Four Year Institutions**

**Location:** Marriott Marquis - Chinatown Room **Sponsor:** Committee on Physics in Two-Year Colleges **Co-Sponsor:** Committee on Physics in Undergraduate Education  
**Time:** 1:30–2:30 p.m. **Date:** Tuesday, July 31 **President:** Martin Shaffer

**EM(A)01: 1:30-2:00 p.m. My Involvement with OK Course Equivalency Project and Articulation**

*Invited – Karen Williams, East Central University, 1100 E. 14th St., PMB D-5, Ada, OK 74820; kwilliams@ecok.edu*

In the past, I submitted course syllabi or revised the course description for a course to be accepted at another university. Courses accepted were then were placed on a matrix. Later, the Oklahoma State Regents for Higher Education set a goal for students to more easily transfer courses between colleges and universities in OK. If courses transferred easily, students would be more likely to finish their degree. I worked this fall on the OK Course Equivalency Project (CEP). Each school sent a representative to develop student learning outcomes for courses in their discipline. I will describe briefly the history of transfer in OK, the CEP, and the approach we used in to develop student learning outcomes. I will also describe an articulation agreement with a two-year college near ECU that was designed to increase our numbers of physics education majors by providing a clear path to ECU.

**EM(A)02: 2:00-2:30 p.m. An Intracity Partnership to Build STEM Capacity**

*Invited – Andrew Ferstl, Winona State University, 175 W Mark St., Winona, MN 55987; aferstl@winona.edu*

Winona State University's Physics Department created an articulation agreement with Minnesota State College Southeast in the spring of 2017. Insights will be shared on why it was done, the goals of the arrangement, and the challenges in doing it.

**Session TOP03: Challenges and Solutions in Physics Instruction at the TYC**

**Location:** Marriott Marquis - Chinatown Room **Sponsor:** Committee on Physics in Two-Year Colleges **Time:** 2:30–3:30 p.m. **Date:** Tuesday, July 31  
**President:** Joe Heafner

*In this topical discussion, we will entertain conversation about issues facing physics faculty in two-year colleges. Come prepared to discuss both positive and negative aspects, and bring proposed solutions for the latter.*

**PLENARY: David Cash**

Location: Renaissance Ballroom

Sponsor: AAPT

Time: 4–5 p.m.

Date: Tuesday, July 31

President: Mel Sabella

**Dispatch from the Front Lines: Confessions of a Science Teacher, Researcher and Government Bureaucrat**

by David Cash, John W. McCormack Graduate School of Policy and Global Studies, UMass Boston



David Cash

In the last year, scientists have taken to the streets in two national marches for science, science curricula in a number of states are under fundamental review, and federal rules that govern the use of science in the U.S. Environmental Protection Agency are being revised. These are just a few of the data points that show that science, scientific research, the science-policy interface, science education and scientific literacy are being defined, re-defined, re-cast, transformed, re-imagined, and re-conceived. This presentation will explore the turbulent world we as science educators and practitioners find ourselves in.

**Session FA: PER: Assessment, Survey Methods and Machine Learning**

Location: Mount Vernon Square A

Sponsor: AAPT/PER

Time: 5:00–6:50 p.m.

Date: Tuesday, July 31

President: Caleb Speirs

**FA01: 5:00-5:10 p.m. Identifying At-Risk Students Using Participation in Weakly Incentivized Activities**Contributed – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506; [stdevore@mail.wvu.edu](mailto:stdevore@mail.wvu.edu)

Cabot Zabriskie, John Stewart, West Virginia University

Early indicators of student success in a class can be important in allocating additional support to those who need it most. Early warning systems, however, often rely on early homework scores or even early assessment scores which are only available after a significant portion of the class has passed. In this study, several measurements including participation in early optional assignments and extra credit opportunities as well as other early measurements of student engagement are examined alongside background measurements of student incoming ability. The relationship between these factors and the student's class grade is explored in an attempt to identify suitable early indicators of student difficulty.

**FA02: 5:10-5:20 p.m. Addressing Student Retention via Frequent Testing and Retesting**Contributed – Brianna Gutmann, University of Illinois at Urbana-Champaign, 1110 W Green St., Urbana, IL 61801; [bgutman2@illinois.edu](mailto:bgutman2@illinois.edu)

Tim Stelzer, Gary Gladding, Morten Lundsgaard, University of Illinois at Urbana-Champaign

Prior to the main physics classes, the University of Illinois offers a preparatory physics course for students who feel underprepared for the calculus-based engineers' sequence. After taking this preparatory course, only about half of the students continue and then pass the target course. This drop includes students who do not enroll in the main sequence following the initial class and students who do not pass after enrolling. To address this issue, we implemented bi-weekly quizzes with re-tests offered on off weeks to encourage students to confront difficult topics and continue to work on them, while also providing students regular feedback. To ease students' transition into the main sequence following the preparatory course, re-takes of exams were also added to the first course in the engineers' sequence. Student retention through the preparatory course and target course, both with these retakes, will be presented.

**FA03: 5:20-5:30 p.m. Can Machine Learning Predict When STEM Students Switch Majors?**Contributed – John M. Aiken, Centre for Computing in Science Education, University of Oslo, Sem Sælands Vei 24, Uio/Fysisk Institutt, Blindern, Oslo 0316 Norway; [johnm.aiken@gmail.com](mailto:johnm.aiken@gmail.com)

Marcos D. Caballero, Michigan State University

As students go through their undergraduate careers, they take courses, interact with other students, and sometimes change their majors. Understanding what factors may act as precursors to major change can help advising faculty understand their students. This work uses data from the Michigan State registrar to predict when students in physics change their major. Our data includes time stamped courses taken, grades, and student demographics. This data set has been used previously to describe the pathways students take into and out of the physics major. Physics Education Research has historically focused on descriptive statistics and short time scales (e.g., concept inventories within single courses). This work expands the scope of what is possible within Physics Education research with predictive models exploring student choice at large time scales.

**FA04: 5:30-5:40 p.m. Understanding Standardized Test Scores Using Machine Learning and Longitudinal Analysis**Contributed – Matthew W. Guthrie, The University of Texas at Austin, 2515 Speedway, C1600, Department of Physics, RLM 14.312, Austin, TX 78712; [mwguthrie@physics.utexas.edu](mailto:mwguthrie@physics.utexas.edu)

Comparing students, schools, and districts to one another in order to form an understanding of performance on a standardized test is common across the country. If the comparison groups aren't carefully chosen, these comparisons are often not useful or can be completely invalid. In this talk, I will discuss the Texas Education Agency's current grouping method, and my attempt to improve this method using multidimensional reduction and clustering on demographic variables for students

attending each high school in Texas. The resulting comparison groups are then used to identify schools that consistently outperform their peers, and to inform qualitative researchers about where to find exemplary schools.

**FA05: 5:40-5:50 p.m. Weekly Online Quizzes Outperform Written Quizzes**

*Contributed – Byron Drury,\* MIT, Room 26-331, Cambridge, MA 02139-4307; bdrury@mit.edu*

*Sunbok Lee, David Pritchard, Michelle Tomasik, MIT*

*Chandra Songh, Univ Pittsburgh*

Starting with standard concept inventories by Singh and others, we created single topic online assessments taking ~½ hour by evening the coverage across subtopics, and including some questions requiring symbolic response. We administered these weekly along with ½ hour on-paper quizzes graded with partial credit in a remedial introductory mechanics course. Optimum reliability of the online quizzes occurred when weighting 1.0 (0.7) for first (subsequent) attempt correct. Both quiz averages correlated well with the traditional hand-graded long problems on the final exam (~0.8), and with the Mechanics Baseline Test online post-test (0.7) [1], but the online quizzes correlated much better with both the concept questions on the final exam and the Mechanics Reasoning Inventory [2]. We conclude that online quizzes are a better measure of overall student ability in mechanics, likely due to the combination of research-developed questions, selection of high discrimination questions, and absence of grading error.

\*Sponsored by David Pritchard

**FA06: 5:50-6:00 p.m. Statistics for Use with Non-parametric Conceptual Evaluation Instruments**

*Contributed – Rebecca Lindell, Tiliadal STEM Education Solutions, 5 N 10th St Suite A-1, Lafayette, IN 47901; rlindell@tiliadal.com*

When studying the effects of two different curricula often the researchers will use a Distracter-driven conceptual multiple-choice instrument or concept inventory to evaluate students' conceptual understanding before and after the different types of instruction. Many of the statistical tests utilized to study these effects are either parametric or non-parametric, but researchers can only use the easier parametric statistical tests, if the instrument meets the assumptions of a normal distribution of scores. Unfortunately due to their distracter-driven nature, these conceptual evaluation instruments are non-parametric due to their distracter-driven nature. As they are non-parametric instruments, it is no longer appropriate to utilize parametric statistical tests, such as t-tests or factor analysis when analyzing the data. In this talk, the researchers will discuss the non-parametric nature of concept-inventories, as well as present appropriate non-parametric statistical tests that should be utilized when analyzing results from these non-parametric instruments.

**FA07: 6:00-6:10 p.m. Comparing Insights from Different Methods for Clustering Multiple-Choice Test Questions**

*Contributed – Mark D. Eichenlaub, University of Maryland, 8413 Potomac Ave., College Park, MD 20740; mark.d.eichenlaub@gmail.com*

*Deborah Hemingway, Edward F. Redish, University of Maryland*

Students taking a multiple-choice test generate more data than simply their final score, and a large class generates far more data than a single statistic can convey. Statistical techniques such as factor analysis and computations on network-based models can help us go from raw data to new insights on student learning, but only if we know how to interpret the results. As a case study in statistical meaning, we contrast results from applying factor analysis and network modularity maximization to data from two new survey instruments created as part of a project to study mathematical meaning-making in introductory physics for the life sciences. We ask what results would be expected given various models of student behavior, what results we actually see, and how quantitative results can go on to inform qualitative research.

**FA08: 6:10-6:20 p.m. Exploring the FCI Using Multi-Dimensional Item Response Theory**

*Contributed – John C. Stewart, West Virginia University, 235 White Hall, West Virginia University, Morgantown, WV 26506; jcstewart1@mail.wvu.edu*

*Cabot Zabriskie, Seth DeVore, West Virginia University*

Despite its wide adoption and use over the past 25 years, the factor structure of the Force Concept Inventory (FCI) remains an active topic of research. Techniques such as exploratory factor analysis (EFA) have hinted that a multi-dimensional structure may exist, but published structures have not been reproduced. Exploratory factor analysis using multi-dimensional Item Response Theory (MIRT) was used to identify a factor structure different from previously published studies. Correlation analysis showed much of the identified structure could be accounted for by correlations resulting from blocked questions, repeated questions types, and correlations through the total score on the instrument. Using expert solutions, we developed a theoretical model of the knowledge structure of the FCI. This model was then refined using MIRT with a constrained parameter matrix. The refined model was shown to be significantly better than the original model proposed by the developers of the FCI.

**FA09: 6:20-6:30 p.m. Multi-Dimensional Item Response Theory and the CSEM**

*Contributed – Cabot Zabriskie, West Virginia University, 135 Willey St., Morgantown, WV 26506-0002; cazabriskie@mix.wvu.edu*

*Seth DeVore, John Stewart, West Virginia University*

Significant attention has been paid to understanding the underlying structure of mechanics conceptual inventories in PER, such as the Force Concept Inventory (FCI) and Force and Motion Conceptual Evaluation (FMCE). However, this same attention has not been directed toward understanding of similar instruments in Electricity and Magnetism. In this study we extend our previous analysis of the FCI using Multi-Dimensional Item Response Theory (MIRT) to the Conceptual Survey of Electricity and Magnetism (CSEM). Using a MIRT analysis of CSEM post-test results from two universities, we are able to better understand the underlying structure in the CSEM and provide practitioners a better understanding of what CSEM results can tell them about their students' learning. We also compare models across institutions to determine what features of the CSEM depend on the student population and instructional environment.

**FA10: 6:30-6:40 p.m. Quantitative Analyses for Valuing Students' Incorrect Responses to Common Assessments**

*Contributed – Trevor I. Smith, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028-1701; smithtr@rowan.edu*

*Kyle J. Louis, Bartholmew J. Ricci, Rowan University*

It is well-documented that students in classes that use research-based instructional methods have higher learning gains on standard research-based assessment instruments than students in traditional lecture-based classes. What is not often discussed is whether or not a student can show improvement by choosing different incorrect answers on the pre-/post-tests. Are some incorrect responses closer to correct than others? We use quantitative analyses of student responses to the Force and Motion Conceptual Evaluation to answer this question by ranking incorrect answer choices from more to less sophisticated (with more sophisticated considered



closer to being correct). We present the assumptions we use to determine which answers are more sophisticated than others, and the analysis methods that are based on those assumptions (item response theory for nominal responses; McNemar-Bowker chi-square test for asymmetries). A unified ranking of incorrect responses provides a mechanism for measuring student growth, not just mastery.

**FA11: 6:40-6:50 p.m. The Force Concept Inventory (FCI) and English Learners**

*Contributed – Alfonso Reina, New York Institute of Technology, 9 Wenyuan Road, Nanjing, China 210046 R.R. China; areina@nyit.edu*

Teaching and assessing English Learners (ELs) in the context of global campuses from American institutions face the challenge of adapting to the cultural background and language skills of students. Here, we describe insights from the implementation of the FCI in various versions (English, Simplified English, and native language) in populations of ELs from various countries, predominantly in China. The performance of students in the FCI is dependent on the form of the FCI given and the English skills of the students. We also use a Cochran-Mantel-Haenszel (CMH) test to identify biases in the different versions of the tests when applied to ELs.

**Session FB: PER: Student Support – Peer Instructors**

**Location:** Marriott Marquis - Tulip **Sponsor:** AAPT/PER **Time:** 5:00–6:40 p.m. **Date:** Tuesday, July 31 **President:** Chris Moore

**FB01: 5:00-5:10 p.m. Student-Centered Teaching: Graduate Teaching Assistants' Expectations and Perceptions of Essential Pedagogical Skills**

*Contributed – Constance M. Doty, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816; Constance.Doty@knights.ucf.edu*

*Erin K. H. Saitta, Jacquelyn J. Chini, University of Central Florida*

As university STEM departments implement more research-based teaching practices, graduate teaching assistants (GTAs) are called into leadership of student-centered classes, recitations and laboratories. However, the GTAs possess varied prior teaching experiences, varied exposure to student-centered learning environments, and varied comfort with interacting with students. Also, models for preparing GTAs vary widely across departments and institutions. Our broader project investigates the use of a mixed-reality classroom simulator to provide targeted practice on pedagogical skills that enhance student learning in student-centered courses. Our theoretical framework of GTA professional development proposes that GTAs' prior and current teaching and learning experiences, pedagogical training, and expectations of the course design impact the effectiveness of future training. Here, we investigated the expectations and perceptions of essential pedagogical skills held by GTAs who led student-centered recitations and Investigative Science Learning Environment labs in physics and inquiry-based labs in chemistry.

**FB02: 5:10-5:20 p.m. Physics Teaching Assistants' Perceptions of a Multiple Choice Problem: Empathy for Students Overshadows Benefits of Formative Assessment**

*Contributed – Melanie L. Good, University of Pittsburgh, 2017 Noble St., Sharpsburg, PA 15215; melanie.l.good@gmail.com*

*Emily Marshman, Chandralekha Singh, University of Pittsburgh*

*Edit Yerushalmi, Weizmann Institute of Science*

In this investigation, we examined physics graduate teaching assistants' (TAs') views about an introductory physics problem posed in a multiple-choice format within the context of a semester-long TA professional development course. The TAs were asked to list the pros and cons of a multiple choice problem, rank the problem in terms of its instructional benefit and the level of challenge it might produce for their students, and describe when and how often they would use it in their own classes if they had complete control of teaching the class. Findings will be presented. We thank the National Science Foundation for support.

**FB03: 5:20-5:30 p.m. Effects of Peer-Interaction on Conceptual Test Performance and Cognitive Load**

*Contributed – Tianlong Zu, Purdue University, 2491 Sycamore Lane, Apt. 9, West Lafayette, IN 47906; tzu@purdue.edu*

*N.Sanjay Rebello, Purdue University*

Cognitive load theory (CLT) posits three types of loads: intrinsic, extraneous and germane. Each has unique implications for learning. Peer interaction has gained popularity in educational setting due to its effect of improving students' conceptual understanding. We investigated whether working in a group influenced conceptual test performance and cognitive loads of students. Cognitive loads were measured by a subjectively rated survey. We asked students to work on DIRECT individually followed by working in a group both as pre- and post-test. The cognitive load survey was administered after each test. We found that when students lacked relevant knowledge, the improvement of performance from working individually to working in groups was not as significant as when they had certain level of relevant knowledge. The cognitive load survey revealed that peer interaction affected performance mainly through affecting intrinsic load.

**FB04: 5:30-5:40 p.m. Learning Assistants and their Contributions to a Curriculum Development Project\***

*Contributed – Manher Jariwala, Boston University, 590 Commonwealth Avenue, Department of Physics, Boston, MA 02215; manher@bu.edu*

*Emily Allen, Andrew Duffy, Boston University*

At Boston University, we are in the first year of an NSF-funded curriculum development project examining the effectiveness of simulations as dynamic visual representations for learning physics concepts. This study is being conducted in a multi-section, algebra-based, introductory physics class for life science students, taught in a highly interactive studio classroom. In addition to the teaching staff of this course, each section employs two undergraduate Learning Assistants (LAs) as key members of the instructional team. We have been investigating how to utilize the insights and experiences of the LAs to support traditional curriculum development methods, drawing on the expertise of the LAs to assist in the design of the curriculum as well as help in its pedagogical implementation. In this talk, we will report on our exploration of this new framework for the use of LAs for education research and course development.

\*Funded by NSF grant DUE 1712159.

**FB05: 5:40-5:50 p.m. The Influence of Learning Assistants' Positioning on How Students Learn and Feel in Class**

Contributed – Hagit Kornreich-Leshem, \* STEM Transformation Institute, Florida International University, 11200 SW 8th Street, VH 166, Miami, FL 33199; hkornrei@fiu.edu  
Sat Gavassa-Becerra, Florida International University

Laird Kramer, STEM Transformation Institute, Florida International University

The increased use of Learning Assistants in active learning classrooms have shown to benefit students' conceptual understanding, overall course performance, retention and graduation rates. However, the implementation of active learning and LAs across disciplines varies and sometimes does not lead to students' full engagement and buy-in. In this case study, we used Hazari's holistic engagement analytical lens to examine how LAs influence students' behavioral, affective and cognitive engagement in class. To gain a deep understanding of class structure, we followed the faculty-LA course team during a five-week module and collected class documents, attended LA-faculty planning meetings, observed classes and conducted informal interviews with LAs and the faculty. Based on this understanding, we developed a student survey that looked at the effects of students' engagement on their science identity. We will discuss preliminary results and future implications to the study of effective active learning classrooms.

\*Sponsored by Dr. Laird Kramer

**FB06: 5:50-6:00 p.m. Learning Assistants' Changing Perception of Teaching**

Contributed – Steven F. Wolf, East Carolina University Department of Physics, 1000 E 10th St., Greenville, NC 27858-4353; wolfs15@ecu.edu

Rohin Gawdi, East Carolina University Department of Physics

Kristine Callis-Duehl, East Carolina University Department of Biology

Daniel Dickerson, East Carolina University Department of MSITE

Joi Walker, East Carolina University Department of Chemistry

East Carolina University has just implemented a Learning Assistant (LA) program in the past year. LAs are undergraduate student instructors that support group learning in large lecture courses, promoting active and interactive learning. One of the goals of ECU's LA program is to increase the number of science teachers. Students have many barriers to entering the teaching profession, many of them self-imposed. We have given our LAs the Perceptions of Teaching as a Profession (PTaP) survey, which is a new research tool designed to gauge students' perceptions of teaching careers. Specifically, PTaP investigates nine categories of student perception of the teaching profession. PTaP includes 55 statements that utilize a Likert scale to study these nine categories and a series of demographic questions. We gave the PTaP to N=28 students in our pedagogy course using a pre-post implementation, and will present preliminary findings.

**FB07: 6:00-6:10 p.m. Learning Assistants as Constructors of Feedback: How Are They Impacted?**

Contributed – Paul C. Hamerski, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824; tallpaul@msu.edu

Paul W. Irving, Daryl McPadden, Michigan State University

Project and Practices in Physics (P-Cubed) is a flipped section of introductory, calculus-based physics, which is designed with a problem-based learning approach where students work in groups on complex physics problems. Learning Assistants (LAs) are critical to the course, where they each function as a primary instructor for four to eight students by asking questions and prompting discussion during class. LAs in P-Cubed also write individualized weekly feedback to each of their students, which is meant to offer suggestions to the student for how to improve their work in class and provide the student with a justification for their in-class grade. We conducted semi-structured interviews with LAs -- selected to portray a broad range of approaches to feedback -- to examine the ways that they construct feedback and how this impacts their own experiences as students taking classes. In this presentation, we compare the reflections and experiences of these LAs.

**FB08: 6:10-6:20 p.m. Analyzing How Faculty-LA Positioning Affects Learning Opportunities**

Contributed – Hannah Jardine, The University of Maryland, 2226 Benjamin Building, College Park, MD 20742; hjardine@umd.edu

In planning meetings with faculty, learning assistants (LAs) can be positioned as instructional collaborators; they can be granted opportunities to provide feedback and evidence about student learning that faculty can use to improve their teaching. However, emerging research demonstrates that the level of LA-faculty collaboration in preparation meetings varies. In this presentation, I use discourse analysis to examine interactions during LA preparation meetings for an introductory biology course, in order to understand how LAs were positioned in this space. Patterns revealed that LAs were most often positioned as non-experts in both content and pedagogy, but occasionally as co-teachers or instructional collaborators. The research also suggests that positioning may be influenced by a variety of contextual, structural, and discourse-related factors. This presentation aims to elucidate some of the factors that may hinder or promote opportunities for faculty to gain useful feedback from LAs on pedagogy and student learning during planning meetings.

**FB09: 6:20-6:30 p.m. Using LAs for Effective and Engaging Transfer Between STEM Disciplines**

Contributed – Ameya S. Kolarkar, Auburn University, 206 Allison Lab, Auburn, AL 36849; kolarkar@auburn.edu

Lack of transfer of skills, knowledge, and applicability between the STEM disciplines is a common problem in STEM education. There are several proposed solutions for certain disciplines, e.g. IPLS. We are using Learning Assistants to effect transfer through dialogical discourse over multimedia channels. This approach has the potential to cover all STEM disciplines. We shall present the advantages and effectiveness of this approach compared to faculty-focused approaches.

**FB10: 6:30-6:40 p.m. Student Outcomes Across Collaborative-Learning Environments**

Contributed – Xochith M. Herrera, CSU Chico, 1080 Columbus Ave., Chico, CA 95926; xherrera@mail.csuchico.edu

Jayson Nissen, Benjamin V. Dusen, CSU Chico

The Learning Assistant (LA) model supports instructors in implementing research-based teaching practices in their own courses. In the LA model undergraduate students are hired to help facilitate collaborative learning activities. Most of these activities have research supporting their efficacy. We investigated if the use of LAs is associated with improved student outcomes beyond the improvement caused by the introduction of these collaborative-learning activities. Using the Learning About STEM Student Outcomes (LASSO) database, we examined student learning from 112 first-semester physics courses that used either lecture-based, collaborative learning without LAs, or LA-supported instruction. We measured student learning using responses from 5,959 students on the Force and Motion Conceptual Evaluation (FMCE) or Force Concept Inventory (FCI). Results from Hierarchical Linear Models (HLM) indicated that LA-supported courses had higher posttest scores than collaborative courses without LAs and that LA-supported courses that used LAs in laboratory and recitation had higher posttest scores than those that used LAs in lecture.

## Session FC: Best Practice in Teacher Professional Development

**Location:** Marriott Marquis - Chinatown Room

**Sponsor:** Committee on Teacher Preparation

**Co-Sponsor:** Committee on Physics in High Schools

**Time:** 5–6 p.m.

**Date:** Tuesday, July 31

**Presenter:** Michael Wittmann

### FC01: 5:00-5:10 p.m. PD of Physics Teacher-Leaders in a Program of Regional PLCs

*Contributed – Smadar Levy, Weizmann Institute of Science, 22 Zufit St., Hod Hasharon, Israel 4535449 ISRAEL smadarlevy@gmail.com*

*Esther Bagno, Hana Berger, Bat-Sheva Eylon, Weizmann Institute of Science*

Teacher-leaders play a major role in teachers' Professional Development (PD) and in the development of Professional Learning Communities (PLCs). However, little is known about the PD of the teachers-leaders themselves. We studied the PD of high-school physics teacher-leaders in a national PLCs program. The teacher-leaders' PLC was led by a team from the Weizmann Institute of Science, while the teacher-leaders simultaneously led regional PLCs of physics teachers. In order to characterize the teacher-leaders' PD we developed a theoretical framework: Physics Knowledge for Teaching and Leading (PKTL). Our framework is based on the frameworks of Knowledge Integration (Linn & Eylon, 2011) and MKT (Ball, Thames & Phelps, 2008).<sup>1</sup> The results show the teacher-leaders' long-term PD in several aspects: their physics knowledge, their knowledge about teacher learning, dissemination of learner-centered practices, and more. Elaborated examples will be presented and implications for PD of teachers and teacher-leaders will be discussed.

1. Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: what makes it special?. *Journal of teacher education*, 59(5), 389-407. Linn, M. C., & Eylon, B. S. (2011). *Science learning and instruction: Taking advantage of technology to promote knowledge integration*. Routledge.

### FC02: 5:10-5:20 p.m. Theory of Planned Behavior as a Lens for Professional Development\*

*Contributed – Alistair G. McInerney, North Dakota State University, 1340 Administration Ave., Fargo, ND 58102; Alistair@McInerney.org*

*Mila Kryjevskaja, Jared Ladbury, Paul Kelter, North Dakota State University*

A North Dakota State University team is designing, implementing, and evaluating a sustainable campus-wide professional development program to encourage the use of active learning in college classrooms. Each cohort of faculty participates in four 2-day workshops and regular Faculty Learning Community meetings over 2 years. To assess the effectiveness of the program, we have incorporated two methodologies common in psychology research: (1) the Theory of Planned Behavior, which utilizes attitudes, norms, and self-efficacy beliefs to predict intentions toward a specific action (e.g. implementation of active-learning), and (2) "retrospective" pre-tests instead of traditional pre-tests. The comparison of post- and retrospective pre-tests has been shown to be more reliable in detecting change when assessing self-report data. A robust set of data from two cohorts, collected over the course of three years, allowed us to probe changes in participants' attitudes, beliefs, and classroom practices, and the links between them.

\*This material is based upon work supported by the National Science Foundation under Grant No. DUE-1525056.

### FC03: 5:20-5:30 p.m. Partnerships for Science Identity: Three Populations of Active Learners (PSI<sup>^</sup>3)\*

*Contributed – Wendy K. Adams, Colorado School of Mines, 1500 Illinois St., Golden, CO 80401; wkadams@mines.edu*

*Kristine Callan, Colorado School of Mines*

We have added a new component to our science teacher preparation program that partners pairs of secondary teacher candidates (TCs) with a team of elementary teachers (ETs), and their elementary students (ESs). The goals of this partnership are to: establish expectations of vertical articulation with TCs, provide strong examples of classroom management for the TCs, empower ETs to teach more science activities, and develop science identities in both ETs and their ESs. Here we will report on the successes and challenges of the first year of this project including how we have worked with different districts to share materials.

\*This work is supported by 100Kin10.

### FC04: 5:30-5:40 p.m. Inquiry as Strategy for STEM Education

*Contributed – Mohammad Bhatti, University of Texas Rio Grande Valley, 1401 West University Drive, Edinburg, TX 78539; muhammad.bhatti@utrgv.edu*

The U.S. National Science Education Standards recommend that science instruction and learning should be well grounded in inquiry. In spite of these efforts, however, little has changed in the way science is taught. Teacher-talk and textbooks are still the primary providers of science information for students. The objective of this talk is to: (a) review the history of inquiry science teaching, (b) define inquiry as a strategy for teaching science, and (c) present the Physics by Inquiry model for in-service middle school science teachers. Amazing results of the implementation of the model and make and take activities will be presented.

### FC05: 5:40-5:50 p.m. Can You Tell Me What Evidence Supports This Theory?

*Contributed – Richard Gelderman, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101-1077; gelderman@wku.edu*

We recognized the needs that would face the teachers in our region, and assembled a strong interdisciplinary team to thoughtfully design the content to maximize learning. This team iterated until we had a schedule that would allow the maximum number of diverse teachers to participate. Funding was acquired to allow us to purchase material to share and to provide stipends, travel reimbursement and support for substitute teachers to allow participants to feel it was worth being part of the project. From the first rounds of workshops we identified top performers with leadership potential. The second round incorporated those teacher leaders into the workshop team. After being presenters alongside the original team, the teacher leaders came together to plan the third round of workshops. That was when we happened to ask "Can you tell me what evidence supports this theory?" and were stunned to hear their responses.

### FC06: 5:50-6:00 p.m. Exposing Physics Majors to Education while Supporting Studio-Style Courses

*Contributed – Brokk K. Toggerson, University of Massachusetts, Amherst, Department of Physics, 666 N. Pleasant St., Amherst, MA 01003-0001; toggerson@physics.umass.edu*

Many departments have few formalized opportunities for physics majors to explore education principles within physics departments. Moreover, teaching a 100-student course in a team-based format as in Michaelsen et al often requires significant in-classroom assistants. At UMass-Amherst, we have been developing a course to meet both of these needs. In our course, students engage with modern PER literature and get hands-on practical experience in a studio-style classroom under the mentorship of one of our department's lecturers. Simultaneously, the students in this course provide the in-classroom support needed for the first semester of our introductory physics for life sciences course. We will present some of the key features of our course, in particular how course assignments both help the department achieve its teaching goals as well as allow students develop real-world products they can use in future job searches.

## Session FD: Computational Physics for the Life Sciences

Location: Congressional Ballroom B

Sponsor: AAPT

Time: 5–7 p.m.

Date: Tuesday, July 31

President: Nancy Beverly

### FD01: 5:00-5:10 p.m. Computationally Concretizing Thermal Physics for IPLS: Goals, Dilemmas, Choices

Contributed – Edit Menuha Yerushalmi, Weizmann Institute of Science, 10 Haim Haviv St., Jerusalem, Israel 9678818; edit.yerushalmi@weizmann.ac.il

Ariel Abrashkin, Haim Edri, Elon Langbeheim, Sam Safran, Weizmann Institute of Science

The physics of mesoscale structure formation - how do many molecules organize themselves into large-scale assemblies - is at the heart of Biological physics. We present the dilemmas and choices underlying an introductory curriculum that gradually builds the knowledge structure required to address this question. The research-based-curriculum was tested in a course for interested and capable high-school students, and refined over three implementation cycles, introducing several shifts from traditional curricula to meet students' limited prior knowledge: Dynamics presented with a focus on motion dominated by frictional and stochastic forces. The step-by-step evolution of many-particle-systems, dominated by spatial randomness, towards equilibrium, is analyzed and pictured by means of computational models. Introductory level equilibrium statistical thermodynamics is presented in the context of particle diffusion involving spatial entropy; as a precursor to analogous treatment of thermal contact. Finally, Monte-Carlo simulations serve to concretize analytical models of structure formation in systems where interactions compete with randomness.

### FD02: 5:10-5:20 p.m. Computationally Concretizing Thermal Physics for IPLS – Paving the Way

Contributed – Haim Edri, The Weizmann Institute of Science, 234 Herzl St., Rehovot, Israel 7610001; edri.haimon@gmail.com

Samuel Safran, Edit Yerushalmi, The Weizmann Institute of Science

Central position papers present a challenging task -- the inclusion of thermal physics as part of the IPLS course. We present the first unit in an introductory science curriculum that uses computational tools to explain the random nature of multi-particle-systems, crucial in statistical physics, while taking into account students' limited prior knowledge. The unit focuses on diffusion – an important generic characteristic of ions in solution and many other bio-molecules, engaging students in constructing a series of computational models intended to align the stochastic nature of random walks with their prior knowledge of Newtonian mechanics. Students analyze the development of particles' trajectories in time at different time scales. This analysis serves to justify the shift from deterministic model of the motion of one or two particles in vacuum, to a model of colloidal particle dominated by frictional and stochastic forces, resulting from the interactions with the many-particles of the solvent.

### FD03: 5:20-5:30 p.m. Computationally Concretizing Thermal Physics for IPLS – From Dynamics to Equilibrium Statistics

Contributed – Ariel Steiner, Weizmann Institute of Science, Harikma 45/3 St., Givat Yearim, Israel 9097000; ariel.steiner@weizmann.ac.il

Ariel Abrashkin, Sam Safran, Edit Yerushalmi, Weizmann Institute of Science

Computational dynamical models were used in the first unit of an introductory science curriculum to concretize the shift from Newtonian dynamics to particle diffusion modeled as a random-walk. In the second unit of the course this is followed by the abstract statistical-thermodynamics treatment of non-interacting systems assuming equal probability of all microstates (spatial configurations). This unit demonstrates the superfluous nature of the random-walk model for diffusion, accounting for the time-evolution of all particle trajectories, when used to describe equilibrium. Students compare the long-time averaged density distributions of random-walk vs. Monte-Carlo simulations anchored in the equal probability assumption and realize that both lead to constant density. Students justify the assumption by examining spatial sampling in a random-walk model for the relevant measurement timescales. This analysis sets the stage for later discussions of entropy and the second law as well as analysis of other systems relevant to life sciences, such as polymeric macromolecules.

### FD04: 5:30-5:40 p.m. Computationally Concretizing Thermal Physics for IPLS – From Spatial to Energy Spreading

Contributed – Ariel Abrashkin, Weizmann Institute of Science, 6 sderot hatzionut, Tel Aviv, Israel 62157 Israel; ariellab2002@gmail.com

Ariel Steiner, Samuel Safran, Edit Yerushalmi, Weizmann Institute of Science

Biological cells consist of molecules in aqueous solution, serving as a thermal reservoir. The analysis of such systems relies on the laws of thermodynamics, and the conceptualization of energy and its associated entropy. We suggest an instructional sequence in which thermal contact is presented in terms of energy diffusion in the system, in analogy to a more concrete context – particle diffusion involving spatial entropy and the second law. Working in a framework of non-interacting particles, having only kinetic energies, enables a simple and concise definition of temperature and thermal equilibration. To illustrate our approach, we demonstrate a simulation-based discovery activity in which students investigate thermal contact between particles occupying the same volume, relevant to biomolecules in solution. Next, potential energy arising from interparticle interactions, crucial for structure formation (e.g. membranes, vesicles), is introduced. In this context, we derive the Boltzmann factor accounting for interactions from the first and second laws.

### FD05: 5:40-5:50 p.m. Computationally Concretizing Thermal Physics for IPLS – From Energy to Complexity

Contributed – Elon Langbeheim, Weizmann Institute of Science, 234 Herzl St., Rehovot, Israel 7610001 Israel elon.langbeheim@weizmann.ac.il

Samuel Safran, Edit Yerushalmi, Weizmann Institute of Science

Structural complexity is quintessential to biological systems that contain many interacting molecules (e.g., cell membranes, cytoskeleton). The derivation of analytical models that explain structure formation in biological systems requires mathematical treatments of entropy and internal energy which may be beyond the reach of introductory students. Monte-Carlo computational models are an alternative path for the analysis of such biological systems. A lattice-based Monte Carlo simulation samples the configurations of the system by starting from an arbitrary configuration, and then alters the location or orientation of each component (e.g., lipid molecule) using random steps. Each step can then change the potential energy of interaction through the variation of the separation of a given component and its neighbors. The Boltzmann factor is used to calculate the acceptance probability of each step, based on the change in potential energy. We will demonstrate how students use this method for modeling processes in complex biological systems.

### FD06: 5:50-6:00 p.m. Introducing Computational Models for Diffusion into IPLS

Contributed – Benjamin William Dreyfus, George Mason University, 4400 University Drive, MSN 3F3, Fairfax, VA 22030; bdreyfu2@gmu.edu

Wolfgang Christian, Davidson College

Haim Edri, Weizmann Institute of Science

The Weizmann Institute's Interdisciplinary Computational Science curriculum, for advanced high school students in Israel, has students develop molecular dynamics simulations that model macroscopic phenomena such as diffusion. The connection between the microscopic and macroscopic phenomena is also a core element of IPLS curricula for undergraduate students in the U.S., such as NEXUS/Physics. We report on preliminary results from a collaboration that is exploring how elements of these curricula can be synthesized, in order to integrate computational modeling into IPLS. This requires examining the interface not only on the level of content, but also the different student populations for which the curricula are designed, and the different goals for the courses.

**FD07: 6:00-6:10 p.m. Adapting Weizmann Institute Material for Use in the United States\***

*Contributed – Wolfgang Christian, Davidson College, PO Box 7133, Davidson, NC 28035-7133; wochristian@ davidson.edu*

*Haim Erdi, Weizmann Institute, Israel*

*Benjamin Dreyfus, George Mason University*

Science is a universal activity and interdisciplinary and international collaborations are common in traditional research but less so in education because teaching material is written in the local language and curricular requirements vary from country to country. This paper describes work done in conjunction with the Weizmann Institute and the Davidson Institute of Science Education in Rehovot, Israel, to study the practicality of sharing material between the AAPT-ComPADRE digital library and the Weizmann Institute. We demonstrate how a collaboration could proceed by adapting a module from a 10th grade “Interdisciplinary Computational Science (ICS): Chemical and Biological Physics” course. This ICS module uses hard-disk molecular dynamics to construct a fundamental molecular framework to a variety of natural phenomena. The module starts with a pre-test to assess prior computational and physics knowledge, is followed by student programming projects, and concludes with an assessment of both computational ability in physics concepts.

\*Supported by the AAPT Living Physics Portal NSF Grants DUE-1624185 and DUE-1733904.

**FD08: 6:10-6:20 p.m. Modeling and Simulation for the Life Sciences**

*Contributed – Peter Hugo Nelson, Guilford College, 4512 Grendel Rd., Greensboro, NC 27410; pete@circle4.com*

Life-science students are introduced to modeling and simulation on day one using a physical “marble game” modeling diffusion. Students then work through a self-study guide introduction to Excel and write their own kinetic Monte Carlo (kMC) simulation of the marble game in a blank spreadsheet. In this guided-inquiry exercise, students discover that Fick's law of diffusion is a consequence of Brownian motion. Subsequent activities introduce students to: algorithms and computational thinking; drug elimination and radioactivity; semi-log plots; finite difference methods (and calculus); the principles of scientific modeling; model validation and residual analysis. Thermodynamics is introduced using kinetic models of osmosis, ligand binding, ion channel permeation and phase equilibria. IPLS students without calculus are not afraid of Excel. They have been able to implement Monte Carlo and finite difference models of topics that usually require ODEs and PDEs. Sample chapters are available for free at <http://circle4.com/biophysics/chapters/>

<http://circle4.com/biophysics/>

**FD09: 6:20-6:30 p.m. Integrating Computation with Science Courses to Bolster Student Understanding**

*Contributed – Odd Petter Sand, CCSE, Dept. of Physics, University of Oslo, P.O. Box 1048 Blindern, Oslo, Oslo N-0316 Norway; oddps@astro.uio.no*

*Marcos D. Caballero CCSE, Dept. of Physics, University of Oslo and Department of Physics and Astronomy, Michigan State University*

*Christine Lindstrøm CCSE, Dept. of Physics, University of Oslo*

In modern science education, computational understanding is a crucial skill for students to learn. At the University of Oslo, Life Science students are now learning computation deeply integrated with biology and mathematics in their first semester. In this course, students use Python to learn scientific modeling with a Jupyter-Hub textbook where the examples are interactive. We are studying how students organize their knowledge in both computation and science when the curriculum is taught in such an integrated way. Here we will outline the integrated approach and present lessons learned and implications for further curricular development in these and similar courses. We also discuss how the use of computational methods may bolster students' conceptual understanding in mathematics, biology and physics.

**FD10: 6:30-6:40 p.m. Modeling and Visualization of Thermal Systems in Introductory and Upper Level Physics**

*Contributed – Jay J. Wang, UMass Dartmouth, 285 Old Westport Rd., North Dartmouth, MA 02747-2300; jwang@umassd.edu*

Thermal physics transcends disciplinary boundaries more than any single subject, and an understanding of the basic concepts is important in nearly every area of science including life and environmental sciences. We describe the modeling and simulation of thermodynamic systems integrated into both introductory and upper-level physics courses. We discuss computational activities based on first-principle simulations involving many-body interactions such as Brownian motion and molecular dynamics. The activities are designed with meaningful, level-appropriate student engagement using Jupyter Python for computation and enhanced visualization with VPython (see gallery at <http://www.faculty.umassd.edu/j.wang/>). We will present actual activities in which students can study concepts such as thermal equilibrium, diffusion, and entropy, and quantify properties including diffusion rates, Maxwell distributions, and equipartition theorem.

**FD11: 6:40-6:50 p.m. Fun with Fluids! Interactive Simulations to Illustrate Fluid Dynamics Concepts\***

*Contributed – Chris Orban, 191 W Woodruff Ave., Columbus, OH 43210; orban@physics.osu.edu*

*Richelle Teeling-Smith, University of Mount Union*

*Chris Porter, Ohio State University*

One of the closest connections between introductory physics coursework and life sciences is through the topic of fluid mechanics. Many textbooks mention an important connection between fluid mechanics and the circulatory system. For example, fluid mechanics dictates how the heart does work to pump blood to the head, and the way that blood flows through blood vessels. The fluid in a fluid mechanics discussion is often depicted as a liquid of a certain color with a velocity vector to show the direction of the flow rather than as a group of particles exhibiting some obvious motion. Thanks to “particle system” algorithms such as Box2D, simulations with dozens of particles can now be rendered in real time and in an interactive way on a typical chromebook. We demonstrate a few simulations of this kind and discuss future possibilities for using this approach these to illustrate fluid mechanics concepts. \*The STEMcoding Project is supported by the AIP Meggers Award and internal funding from OSU.

\*The STEMcoding Project is supported by the AIP Meggers Award and internal funding from OSU.

**FD12: 6:50-7:00 p.m. Polymer Chain Translocation in Post Array Induced by Arrangement Differ**

Contributed – Zhaohui Wang, No.2 Dongnandaxue Road, Nanjing Jiangsu, China 211189 CHINA; 845205357@qq.com

Jiahua Lu

Xingchen Zhang

We demonstrate that the arrangement differs of posts have significant effect on the translocation of polymer chains which are embedded in the post arrays by using Monte Carlo algorithm. Moreover, by changing the diameter of the posts, we find that the associated translocation times are strongly affected by the structure of the post array. Hence, a new micro-fabricated device that is used to separate deoxyribonucleic acid (DNA) by molecular weight can be designed using this idea. Moreover, this study can help us to develop a better understanding on the passages of polymers across membranes in nature.

**Session FF: Experiences in Washington Policy Internships and Fellowships**

**Location:** Marriott Marquis - Magnolia **Sponsor:** Committee on Graduate Education in Physics **Co-Sponsor:** Committee on Science Education for the Public  
**Time:** 5-7 p.m. **Date:** Tuesday, July 31 **President:** Bruce Mason

**FF01: 5:00-5:30 p.m. Opportunities in Science Policy: AAAS S&T Policy Fellowships**

Invited – Salaeha Shariff, American Association for the Advancement of Science, 1200 New York Ave. NW, Washington, DC 20005; sshariff@aaas.org

This session will explore opportunities for scientists and engineers to apply their training to national and international initiatives, contribute to the policy-making process, identify transferable skills that can be developed and applied to a successful career in science policy, and discuss the rewards of collaboration/broad science engagement. Session will delve into opportunities to contribute scientific & technological leadership and innovation to design and execute solutions to address societal challenges. It underscores the influence of science and innovation on the policy-making process and the impacts of policy-making on the scientific enterprise. Provides strategies and resources to learn and engage in policy across career stages.

**FF02: 5:30-6:00 p.m. Career Transition: Observational Astrophysicist to Congressional Staffer**

Invited – Sara Barber, U.S. House of Representatives, 1 3rd Street NE Apartment A, Washington, DC 20002-7302; sara.d.barber@me.com

A few months after defending my dissertation on remnant planetary systems orbiting white dwarfs, I found myself working alongside the staff of the House Committee of Science, Space, and Technology as a science policy fellow. During my year with the Space Subcommittee I helped conduct oversight of NASA, prepare Committee Members for hearings and legislative markups, and meet with stakeholders. At the end of my fellowship, I was invited to stay on as professional staff. Since then, my portfolio has expanded to include oversight of NSF, management of large research facilities, and STEM education and diversity. As a member of the Committee staff, I work every day to provide our Members with the information they need to make informed policy decisions. The transition from science to policy was not seamless, but I am fortunate to have found a career that challenges me and gives me a strong sense of purpose.

**FF03: 6:00-6:30 p.m. Physics, Policy, & Politics – In DC and Beyond**

Invited – Phillip W. Hammer, AIP, One Physics Ellipse, College Park, MD 20740; pwhammer@gmail.com

My mission as a physicist is to be a scientist engaged in the world so that I can contribute to a more just and equitable society. I left research early in my career to pursue my mission in ways that suited my skills and interests, starting with an APS Congressional Science Policy Fellowship; to serving on my local school board; to working in a science museum; to advancing education, policy, and diversity at AIP. I will illustrate various points in my career with a focus on personal phase transitions, opportunity, and eyes-wide-open entrepreneurship within the rich environments of Washington, D.C., and local communities.

**FF04: 6:30-7:00 p.m. The Physics of Politics**

Invited – Andrew Zwicker, Princeton University, Plasma Physics Lab, PO Box 451, Princeton, NJ 08543; azwicker@princeton.edu

What role should a scientist play in politics at all levels of government? Do we have any more of an obligation to participate in the political process than others? While policy issues of a technical nature are clearly within the natural comfort zone of a scientist, is a science background equally as valuable in dealing with the economic issues, education policy, or social issues? In this talk, I will offer my perspective on these questions and others as the first physicist ever elected to the NJ Legislature and as Chair of the NJ General Assembly's Committee on Science, Innovation, and Technology.

**Session FG: Integrating History of Science into Physics Courses**

**Location:** Marriott Marquis - Cherry Blossom **Sponsor:** Committee on History and Philosophy in Physics **Time:** 5-7 p.m. **Date:** Tuesday, July 31  
**President:** Scott Bonham

**FG01: 5:00-5:30 p.m. History in Physics Teaching and Physics in History Teaching**

Invited – Robert A. Morse, St. Albans School Emeritus, 5530 Nevada Ave., Washington, DC 20015-1784; ramorse@rcn.com

John S. Campbell,\* St. Albans School

In this talk we discuss how to incorporate the history of physics in the designing and teaching of a physics class as well as a history class. Influenced by the Project Physics Course, Bob has had students recreate historical experiments in an effort to build student understanding and learn how we came to understand the physical world. John has developed an elective history course spanning the late 18th century and early 19th century when science and technology had a popular role in the intellectual life of arts and letters. He has called on Bob to give a few demonstration lectures on biographical and scientific aspects of two major scientists of the era, Franklin and Faraday. An essential motivation for us has been to intrigue and engage students through both hands-on learning and the compelling narratives and discoveries of the past.

\*Sponsored by Robert A. Morse

**FG02: 5:30-6:00 p.m. Guiding Students through Great Physics Texts**

*Invited – Kerry Kent Kuehn, \* Wisconsin Lutheran College, 8800 West Bluemound Road, Milwaukee, WI 53226-4699; kerry.kuehn@wlc.edu*

“Does every object have weight?” If so, “how do you know?” Questions like these appeal to the sense of wonder and natural inquisitiveness that attract many students to the study of science. Moreover, such broadly posed questions provide both a motivation and a natural avenue for introducing some of the technical aspects of scientific theories. During the past decade, I have developed and taught a four-semester introductory physics curriculum at Wisconsin Lutheran College based on the careful reading, analysis and discussion of foundational texts in physics and astronomy—texts such as Galileo’s *Starry Messenger*, Pascal’s *Equilibrium of Liquids*, Maxwell’s *Theory of Heat*, and Einstein’s *Relativity*. In this talk, I will explain how and why I developed this curriculum, and also some of the challenges which arise when attempting to incorporate history and philosophy into an introductory physics curriculum.

\*Sponsored by Scott Bonham.

**FG03: 6:00-6:30 p.m. Integrating Conceptual History with Physics Content**

*Invited – Chuck Winrich, Babson College, 231 Forest St., Babson Park, MA 02457-0310; cwinrich@babson.edu*

*Peter Garik, Andrew Duffy, Boston University*

*Yann Benétreau-Dupin, San Francisco State University*

*Luciana Garbayo, University of Central Florida*

The Improving the Teaching of Physics (ITOP) Project at Boston University is a professional development program for high school physics teachers. Our courses combine physics content with the conceptual history of physics and readings from physics education research (PER) literature. The content of ITOP courses includes mechanics, electricity and magnetism, optics, thermodynamics and modern physics. Participants are introduced to the development of concepts in parallel with the physics content to better understand the nature and development of scientific theories. PER literature suggests that student misconceptions often mirror historical ideas, so the conceptual history also contributes to the discussions of student learning. We present examples of conceptual history exercises used in the ITOP classes. These exercises are epistemic games to foster active engagement with the historical conceptions of physics. We will present evaluation data of the ITOP program, and discuss the integration of historical content into participants’ physics classes.

**FG04: 6:30-6:40 p.m. Science and the French Revolution**

*Contributed – Ruth H. Howes, Ball State University 714 Agua Fria St., Santa Fe, NM 87501; rhowes@bsu.edu*

Prior to 1789, French scientists were well-educated men who could afford to equip laboratories and libraries. These scientists were members of the bourgeoisie or nobility, and participated in the French Academy of Sciences trying to improve French agriculture, commerce, and weaponry. These men supported innovations including notably the metric system and played leading roles in Paris and the rest of France. By 1793, the rest of Europe, where monarchs were threatened by the French ideals, declared war on France. The French met their fear by establishing the Committee on Public Safety, a dictatorship led by the formidable Robespierre, which guillotined several excellent scientists. The prosecutor, Antoine Foquier-Tinville, answered a colleague of the chemist Lavoisier, who pleaded for Lavoisier’s life by perhaps apocryphally saying, “The Republic has no need for scientists.” The worth of scientists was not reestablished until the Napoleonic era.

**FG05: 6:40-6:50 p.m. Divine Émilie – Fictional Dialogues With a Real and Bright Woman**

*Contributed – Lutz Frank Kasper, University of Education Schwäbisch Gmünd – Physics Department, Oberbettringer Str. 200, Schwäbisch Gmünd, Baden-Württemb. 73525 Germany lutz.kasper@ph-gmuend.de*

Our protagonist is Émilie du Châtelet, also known as divine Émilie. Although women in early 18th century were barred from entering universities Émilie was privately educated by prominent teachers, such as Maupertuis. Moreover she conducted an affair with Voltaire that lasted many years. They lived together in a chateau where they built a laboratory and a scientific library to match the universities of their time. In 1737 the Paris Academy announced a handsome amount of prize money for the best scientific essay on the subject “The Nature of Light and Heat.” Voltaire, a fervent advocate of Newton’s ideas, entered the competition. Unbeknown to him, Émilie took part, too. In her anonymous essay she proposed ideas that basically anticipated the postulation of thermal radiation, similar to experiments by Herschel some 80 years later. In our talk we will show details and how we integrate this approach into physics teacher education.

**FG06: 6:50-7:00 p.m. History of Sucker and Vacuum Experiments**

*Contributed – Kaya Sakashita, \* Tokyo University of Science, Futaba Bld. 1-3 Kagurazaka, Shinjuku, 162-8601 Japan mode\_midnight20@hotmail.co.jp*

*Koji Tsukamoto, Chiba Institute of Science*

A sucker is used to demonstrate the sensation of atmospheric pressure. Leather suckers are mentioned in 18th century introductory physics textbooks. These books describe children were playing by pulling up a stone by using a sucker suspended on a string in towns such as London in those days. We found that children’s play using suckers was prevalent in the 17th century in Europe. A void is created in a sucker when a force acting on it is considered the same as the vacuum created by Torricelli. In addition, pulling two suckers attached together is considered to have the same effect as that observed in an experiment conducted by Otto von Guericke at Magdeburg. Therefore, it seems that suckers are the cheapest demonstration apparatus to teach about vacuum. We propose the history of the invention of the sucker and connect it to the history of the study of vacuum.

\*Sponsored by Koji Tsukamoto

## Session FH: Professional Development: Effects on Physics Teachers

Location: Marriott Marquis - Dogwood Sponsor: Committee on Physics in High Schools Time: 5–7 p.m. Date: Tuesday, July 31 President: Mohan Aggarwal

### FH01: 5:00–7:00 p.m. Overview of APEX Project\*

Invited – Jim Nelson, Sante Fe College, 6871 SW 89th Way, Gainesville, FL 32608; nelsonjh@ix.netcom.com

NSF awarded a physics enhancement grant to Alabama A&M University and its partners: University of Alabama, AAPT/PTRA Program, Alabama School Systems, and Alabama Science In Motion (ASIM) to conduct a five-year project addressing secondary physics needs of Alabama. The project, entitled “Alliance for Physics Excellence” (APEX), goal is to increase the number of undergraduates in physics who plan to become teachers, provide professional development for in-service physics teachers, and the number of underrepresented individuals who study and teach physics at all levels in Alabama. APEX is transforming physics education in Alabama by enabling high school teachers to acquire a deeper knowledge of physics content and employ more effective pedagogical strategies based on educational research, thus enabling students to achieve higher knowledge gains. Come meet the APEX leaders who will share their vision, details of project, and results achieved too date.

\*The APEX study is supported by NSF Grant DUE 1238192.

### FH02: 5:00–7:00 p.m. Attending to Learners' Thinking: Classroom Results of Using Diagnostic Instructional Tools\*

Invited – James A. Minstrell, Facet Innovations, 1314 NE 43rd St., Ste 207, Seattle, WA 98105; JimMinstrell@FacetInnovations.com

Ruth Anderson, Facet Innovations

Research on how students' learn has promoted the use of activities to increase engagement of students' thinking, to inform teachers of student learning challenges, and to choose or design instruction to foster deeper learning. Attending to student thinking and monitoring conceptual development through ongoing diagnostic formative assessment are two key aspects of the APEX approach to instruction. Over the last five years, APEX teachers have used online resources at Diagnoser.com to monitor and support their students' conceptual learning in physics. They have used elicitation activities to explore students' initial ideas around science concepts, diagnostic question sets to monitor their conceptual development, and information from the automated Teacher Report to help them target instruction for specific learner challenges. In this session, we will explore the student learning results for teachers engaging in the APEX instructional approach.

\*This study has been supported by NSF Grant DUE 1238192. Content, ideas, and results are those of the authors and do not necessarily represent those of the National Science Foundation.

### FH03: 5:00–7:00 p.m. Impact of Physics Professional Development on Teaching and Student Learning

Invited – Dennis Sunal, University of Alabama, Box 870232, Tuscaloosa, AL 35487-0232; dwsunal@ua.edu

Marsha Simon, James W. Harrell, Cynthia Sunal, University of Alabama

The investigation centered on the impact of professional development, guided by the implications of a needs assessment, on physics classroom reform among a statewide, diverse sample of teachers. The study included 75 teachers from this population where classrooms were visited multiple times over three years during physics focused professional development experiences. Results of observer visits found that classroom reform fostered significant differences in the way physics teachers structured their classrooms, conducted teaching, and engaged students. Increased student outcomes were found to be related to the amount of classroom reform implemented. The findings were supported in each of the three parallel studies conducted using a convergent parallel mixed method research design. The results provided a rationale for continued professional development focused on reform in physics classrooms among experienced physics teachers.

### FH04: 5:00–7:00 p.m. Measuring Knowledge of Formative Assessment of Force and Motion

Invited – Marilyn M. Stephens, University of Alabama 2218 Trenton Drive Tuscaloosa, AL 35406 United States mmstephens@crimson.ua.edu

This session discusses the analysis of an instrument to measure physics teachers' formative assessment knowledge of force and motion as an important component of their pedagogical content knowledge (Shulman, 1986; 1987; Magnusson, et al., 1999). As expectations from Next Generation Science Standards (NGSS Lead States, 2013), call for assessment to meet the goals of science education; the assessments must determine not only what the students know, but also serve as a means of learning. The importance of a short, validated instrument that measures physics teachers' topic-specific formative assessment knowledge and the incorporation of this knowledge into their classroom practice is critical for science teacher education and professional development programs to ensure effective physics instruction.

### FH05: 5:00–7:00 p.m. Comparing Physics Teachers Experiencing Differing Professional Development Models

Invited – Justina Ogodo, The Ohio State University, 285B Arps Hall, 1945 N. High St., Columbus, OH 43035; ogodo.1@osu.edu

This study examined the effect of participating in a physics-focused professional development on the instructional practice of advanced placement physics teachers. The teachers who experienced the additional in-service training were compared with the other physics teachers who had little or no additional training beyond the College Board. Data sources included pre- and post-classroom observations, interviews, and surveys. Results from the analysis suggest that a) there was a large treatment effect difference between the teachers who experienced the training and those who did not receive additional training; b) the participating teachers developed increased levels of pedagogical content knowledge (PCK) after the intervention; c) their enhanced PCK influenced the instructional practice used; and d) contextual factors had minimal influence on the teachers' instructional practice. These findings represent an initial empirical evidence of the influence of targeted intervention on the instructional practice of the participants.

## Session FI: Promoting Student Clubs and Cohorts

Location: Marriott Marquis - Scarlet Oak Sponsor: Committee on Physics in Two-Year Colleges Time: 5–6:30 p.m. Date: Tuesday, July 31 President: Elizabeth Schoene

### FI01: 5:00–5:30 p.m. SPS: Best Practices for Undergraduate Clubs

Invited – Brad R. Conrad, SPS/ American Institute of Physics, 1 Physics Ellipse, College Park, MD 20740; bconrad@aip.org

This interactive talk will discuss the best practice on making SPS chapters and undergraduate groups vibrant focal points for the department. Department health, best practices for both students and advisers, and an SPS undergraduate checklist will be discussed. Time will be devoted to identifying strategies for both students and faculty to affect change within their departments to make the undergraduate experience and department everything it can be. A department is more than just



problem sets, exams, and lab reports; it's about forming a strong community, support, networking, leadership skills, and developing strategies that can assist students and advisers throughout your career.

**FI02: 5:30-6:00 p.m. Research and Design Cohorts at the Community College**

*Invited – Gregory Mulder, Linn-Benton Community College, 6500 Pacific Blvd. SW, Albany, OR 97321; mulderg@linnbenton.edu*

When students begin their college career as a science or engineering major, they often envision themselves taking part in exciting experiments and grand engineering projects. Instead, a large number of freshman find themselves taking writing, general education and remedial math classes. At Linn-Benton Community College we have created Research and Design Cohorts (RDCs) as a method of providing students a low-stress high-impact project that links new students with 2nd and 3rd year students and faculty while providing students an authentic research experience. Our RDCs include an Underwater Remotely Operated Vehicle team and a Space Exploration team. In this talk I will discuss: the path we took to create these RDCs, RDC benefits to student learning and career paths, new access to internships and grants that the RDCs have afforded us, faculty workload, and some of the research that suggests that research experiences for undergraduates improve retention and graduation.

**FI03: 6:00-6:10 p.m. The Flavor of Student Clubs at a Large TYC and a Small TYC**

*Contributed – Tony Musumba, Bismarck State College, 1500 Edwards Ave., Bismarck, ND 58506; tony.musumba@bismarckstate.edu*

*Greg Mulder, Linn-Benton Community College*

We explore science clubs at a small Two Year College: Bismarck State College in North Dakota and at a large Two Year College: Linn-Benton Community College in Oregon. It seems like the most active clubs are involved in engineering activities like High Altitude Ballooning(HAB), Remotely Operated Underwater Vehicle (ROV) and Robotics. Student and Faculty leadership is vital in sustaining these clubs from year to year.

**FI04: 6:10-6:20 p.m. The SPS Chapter at Austin Community College – Lessons Learned**

*Contributed – Paul Williams, Austin Community College, ACC Highland Campus 6101 Airport Blvd., Austin, TX 78752; pwill@austincc.edu*

Maintaining ongoing student organizations year over year poses significant difficulties in community college environments. Community college students are typically commuter students and only active in clubs for a one- to two-year period and so ongoing student participation may not be sufficient to provide continuity to the organization. Austin Community College (ACC) is now in its fifth year of maintaining a vital and active SPS chapter. Some of the factors that have contributed to the vitality include institutional support through ACC's Student Life Program, a room for student use, and collaboration with other student organizations. This presentation will share some of the factors that have helped maintain the organization as well as some of the pitfalls.

**Session FJ: PTRA: Hollywood Physics**

**Location:** Marriott Marquis - Silver Linden **Sponsor:** Committee on Physics in Pre-High School Education

**Co-Sponsor:** Committee on Physics in Undergraduate Education **Time:** 5–6:30 p.m. **Date:** Tuesday, July 31 **President:** Kenric Davies

**FJ01: 5:00-6:30 p.m. PTRA: Hollywood Physics**

*Invited – Kenric Davies, Frisco ISD, PTRA, 1508 Castle Creek Dr., Little Elm, TX 75068; kenric.davies@gmail.com*

Participants will break down scenes from movies like “Back to the Future,” “The A-Team,” “Gone in 60 Seconds,” “Abraham Lincoln Vampire Hunter,” and more! Participants will use physics concepts such as Kinematics, Projectile Motion, Force, and Momentum while trying to answer the age old movie question “is that really possible?”

**Session FK: Reducing the Gender Gap in Undergraduate Physics**

**Location:** Meeting Room 2 **Sponsor:** Committee on Women in Physics **Co-Sponsor:** Committee on Physics in Undergraduate Education

**Time:** 5–7 p.m. **Date:** Tuesday, July 31 **President:** Chandralekha Singh

**FK01: 5:00-5:30 p.m. STEP UP 4 Women: Supporting Teachers to Encourage the Pursuit of Undergraduate Physics for Women\***

*Invited – Zahra Hazari, Florida International University 11200 SW 8th St Miami, FL 33199 zhazari@fiu.edu*

*Geoff Potvin, Laird Kramer, Raina Khatri, Florida International University*

*Theodore Hodapp, Kathryne Woodle, American Physical Society*

*Robynne Lock, Texas A&M Commerce*

*Rebecca Vieyra, Beth Cunningham, American Association of Physics Teachers*

While nearly half of the students taking physics in high school are women, only a fifth of the students interested in physics majors in college are women. This talk will present the framework and motivation for the STEP UP 4 Women Project, a nationwide initiative to mobilize and help high school physics teachers better engage women in physics and, by doing so, substantially increase the number of women majoring in physics nationally. The project draws on the extant research evidence to develop, refine, and propagate strategies that facilitate the physics identity development of young women. The evidence-based strategies will be part of a national campaign to support high school physics teachers to inspire a new generation of women physicists. For more information or to join the movement, visit [www.stepup-4women.org](http://www.stepup-4women.org).

\*This work is supported by the National Science Foundation under Grant No. 1720810, 1720869, 1720917, and 1721021.

**FK02: 5:30-6:00 p.m. Stereotype Threat and the Impact of Evidence-based Active Engagement Instruction on the Gender Gap\* in Introductory Physics**

*Invited – Alexandru Maries, University of Cincinnati, 345 Clifton Court, Cincinnati, OH 45220; mariesau@ucmail.uc.edu*

*Nafis I. Karim, Chandralekha Singh, University of Pittsburgh*

Prior research has found that male students often outperform female students in introductory physics classes, particularly on standardized conceptual assessments such as the Force Concept Inventory, a difference referred to as the “gender gap”. Other researchers have found that stereotype threat, i.e., activation of a negative stereotype about a particular group in a test-taking situation, can lead to deteriorated performance of the stereotyped group, which may partly account for the gender gap. Here, we describe the results of several studies investigating the gender gap in introductory physics and its relation to stereotype threat. For example, we explore the impact of asking students to indicate their gender before taking a test on students’ performance on standardized tests as well as the impact of telling students a standardized test (on which a gender gap had previously been found) is gender neutral. We also discuss the extent to which students believe the gender stereotype (that men generally outperform women in physics) and how their beliefs are related to their performance. Finally, we discuss the impact of evidence-based active engagement instructional strategies on the gender gap.

\*Work supported by the National Science Foundation

**FK03: 6:00-6:30 p.m. Gender Differences in Students’ Motivational Characteristics: Alarming Trends**

*Invited – Emily M. Marshman, University of Pittsburgh, 100 Allen Hall, 3941 O’Hara St., Pittsburgh, PA 15260; emm101@pitt.edu*

*Yasemin Kalender, Christian Schunn, Timothy Nokes-Malach, Chandralekha Singh, University of Pittsburgh*

Despite some efforts to encourage women to pursue majors from STEM disciplines, the percentage of women majoring in physics remains low. Moreover, relatively little is known about the differences between the attitudes of men and women and how these attitudes are related to performance outcomes in physics courses. We performed a longitudinal analysis of students’ motivational characteristics. The analysis involved administering pre and post motivation surveys in introductory physics courses for engineers and scientists which assessed, e.g., students’ self-efficacy, grit, fascination with physics, and theory of intelligence. Pre and post conceptual tests were also administered to the students. The differences between male and female students’ motivational characteristics and the relationship between their motivational characteristics and performance on conceptual surveys in physics was examined. In particular, we found that females had lower self-efficacy than males at all performance levels in both Physics 1 and Physics 2. The self-efficacy gaps continued to grow throughout the introductory physics course sequence. The findings were persistent, regardless of course format (i.e., traditional or flipped) and instructor. We also found that females’ self-efficacy is negatively impacted by their experiences in introductory physics courses, and this finding was persistent across various instructors and course formats. We discuss the detrimental short-term and long-term impacts of females’ inaccurate assessments of their capability and performance compared to similarly performing males. We thank the National Science Foundation for Support.

**FK04: 6:30-7:00 p.m. Using Data to Increase Women’s Representation in Undergraduate Physics**

*Invited – Rachel Ivie, \* American Institute of Physics, 1 Physics Ellipse, College Park, MD 20740; rivie@aip.org*

Are there gender differences in the reasons for persistence in a physics major? Studies of persistence and attrition often focus on STEM majors in general, but the situation in physics is likely to be different due to the lower representation of women in physics compared to other STEM fields. Literature shows that the process of deciding on a major is complex, and that many students start college with the intention to major in one area, but switch to another. We need more data about whether there are gender differences in the factors that encourage students to persist in physics, to change to a physics major from some other major, or to leave physics after expressing an initial interest. In this talk, I will discuss AIP’s plans to start collecting the type of data that is needed for a better understanding of gender differences in persistence and attrition for physics majors.

\*Sponsored by Chandralekha Singh

**Session FL: Research Traditions within PER: Perspectives of the Field from Experienced Researchers**

**Location:** Mount Vernon Square B **Sponsor:** Committee on Research in Physics Education **Time:** 5–7 p.m. **Date:** Tuesday, July 31 **President:** Amy Robertson

**FL01: 5:00-5:30 p.m. PER as a Multidimensional Space: Current Work and Expanding Horizons**

*Invited – Rosemary Russ, University of Wisconsin, Madison, 225 N. Mills St., 210 Teacher Education Building, Madison, WI 53706; rruss@wisc.edu*

*Tor Ole B. Odden, University of Oslo, Norway*

Over the last several decades, Physics Education Research has abundantly grown in both quantity and kind. With our field growing in so many directions, we have an opportunity—and responsibility—to pause and take stock both of where we’ve been and where we might go in the future. In this work, we draw on our experiences within the broader field of education to construct a multidimensional map of the space of research. For individuals, this map can provide an entry point into the vast and complex world of educational research. For our field, this map allows us to both systematically explore the current state of our field, and identify some ways we might purposefully expand moving forward. We conclude by highlighting the numerous factors that play into the multidimensionality of our research, and how this multidimensionality can drive our research trajectories forward.

**FL02: 5:30-6:00 p.m. Investigating Introductory, Advanced, and Teacher Knowledge Using the Resources Framework\***

*Invited – Michael C. Wittmann, University of Maine, 5709 Bennett Hall, Orono, ME 04469-5709; mwittmann@maine.edu*

In my work, resources are small-grain ideas or procedures which are useful when solving a problem. Starting from a knowledge-in-pieces tradition in the 1990s, I have often used resources to help analyze data or used data to advance our understanding of the resources framework. In more recent work, issues about activation and attention to resources have come to play a role, as well. In this talk, I describe three studies on mechanical waves, the use of mathematics in physics, and teacher knowledge of student ideas, and unpack how the resources framework played a role in each. I discuss the behind-the-scenes issues (professional and personal) that influenced the details of the work in each study and describe how the framework can apply to both clinical studies using written data and more ethnographic video data gathered when I was a participant in the teacher professional development community being studied.

\*Supported in part by NSF grants 0633951, 0962805 and 1222580.

**FL03: 6:00-6:30 p.m. The Roles of Engagement: Network Analysis in Physics Education Research**

*Invited – Eric Brewe, Drexel University, 32 S. 32nd St., Disque Hall #816, Philadelphia, PA 19104; eb573@drexel.edu*

Network analysis has a relatively short history in Physics Education Research. One might not even consider it a research tradition. However, it is fairly distinct from other statistical approaches and has a unique set of methodological and theoretical commitments that distinguish it from other research traditions. Many, though not all, of the projects I have been involved in over the last 10 years have included network analysis. During this time, my thinking about data and the role of relationships in education have co-evolved. This talk will detail some of the ways that I have come to consider networks and how network thinking has changed my views about education as a complex dynamical system. The goal of this talk is not necessarily to encourage people to use network analysis, but instead to provide some perspective on how adopting network analysis as a methodology has influenced my conceptualization of education.

**FL04: 6:30-7:00 p.m. Panel of Invited Speakers**

*Invited – Amy D. Robertson, 3307 Third Ave W, Suite 307, Seattle, WA 98119-1997; robertsona2@spu.edu*

*Rosemary S. Russ, Tor Ole B. Odden, University of Wisconsin - Madison*

*Michael C. Wittmann, University of Maine*

*Eric T. Brewe, Drexel University*

In the final 30 minutes of this session, we will host an interactive panel discussion with the invited speakers.

**Session FM: Writing in the Physics Curriculum: Objectives, Implementation, and Assessment II**

**Location:** Meeting Room 3    **Sponsor:** AAPT    **Time:** 5–6 p.m.    **Date:** Tuesday, July 31    **President:** Brian Lane

**FM01: 5:00-5:10 p.m. Connecting Writing in Physics to General Education Writing Courses**

*Contributed – Bradley K. McCoy, 1040 W Calle de la Luna #4, Azusa, CA 91702-7000; bmccoy@apu.edu*

While writing in physics courses is valuable in its own right, students are likely to have greater success in their physics writing assignments and to learn more about how writing in the sciences is related to other forms of writing if we explicitly build on their learning from general education writing courses. In this session, we will survey some of the values and pedagogies common within first-year writing courses including writing as a process, writing in community, the role of research in writing, and rhetorical analysis of discourse communities and genres. We will discuss the unique opportunities that scientific writing presents for developing students' rhetorical awareness and flexibility as writers.

**FM02: 5:10-5:20 p.m. Writing-Intensive Intermediate Physics Courses**

*Contributed – Michael Burns-Kaurin, Spelman College, Campus Box 220, 350 Spelman Ln SW, Atlanta, GA 30314-7562; mburns-k@spelman.edu*

*Christopher Oakley, Spelman College*

To fulfill a college requirement that students take two upper-level writing-intensive courses, we previously modified Oscillations & Waves and will modify Advanced Laboratory. This talk will present the assignments, evaluation, and features of the courses that make the courses writing-intensive. These features include peer review, multiple drafts of a term paper with rubrics that shift to more emphasis on the writing skills, and use of low-stakes writing throughout the course.

**FM03: 5:20-5:30 p.m. Incorporating Questions Requiring Written Responses on Homework and Exams**

*Contributed – D. Blane Baker, William Jewell College, 500 College Hill Campus Box 1130, Liberty, MO 64068-1896; bakerb@william.jewell.edu*

Many studies indicate that success in the 21st century requires not only basic knowledge but also skills in critical thinking and communication. In most physics courses, students gain plenty of experience in certain aspects of critical thinking through solving quantitative problems; however, they often lack experience in formulating written arguments. In an effort to develop these skills, we have incorporated conceptual and critical reasoning questions requiring written answers as part of homework and exams. This talk will provide examples of questions asked over the past four years in our General Physics courses, along with selected student responses. In addition, student feedback and outcomes will be discussed.

**FM04: 5:30-5:40 p.m. The Communication Assessment in Junior Physics Lab**

*Contributed – Karen Williams, East Central University, 1100 E. 14th St., Ada, OK 74820; kwilliams@ecok.edu*

Written and oral communication in physics comes in many forms: words, equations, tables, photographs, and graphs. In Junior Physics Laboratory students are expected to be able to write formal lab reports. The Jr. Lab Report Rubric is used to assess each report. Students are also required to design a project and write a group report that requires them to plan communication and get data and methodology from other groups to summarize their findings. I call this their "NASA-like" project. Students are also required to complete a research project of their choosing and communicate about their project by preparing a presentation (Powerpoint) and presenting it orally. The Design Lab Rubric is used to score their presentations and a rough presentation rubric is used by their peers. These communication assessment items and rubrics will be discussed.

**FM05: 5:40-5:50 p.m. Predict, Test, Reflect: Surprising Learning Through Lab Notebooks**

*Contributed – Catherine M. Herne, SUNY New Paltz, 58 S. Manheim Blvd. #7, New Paltz, NY 12561; herne@newpaltz.edu*

The humble lab notebook is a source of powerful learning about science and about writing. I present the advanced laboratory notebook model: predict, test, reflect. Through clear instructions, iterative process, and a detailed rubric students' lab notebooks become useful to them. After a few weeks of feedback, their notebooks are more richly descriptive and their reflections on the experimental process more effective. They begin to understand the value of careful predictions, relevant tests, and nuanced reflections. Through attention to the notebook students begin to own the scientific method. As students progress in scientific thinking, their writing evolves as well. First, they move from trying to write what the instructor wants to what will be useful to them. The final assignments rewrite the informal notebook into key

sections of an article. During one semester these undergraduates have used their notebook to achieve fundamentals of writing for other scientists.

### **FM06: 5:50-6:00 p.m. Writing About Numbers: A Project-based Computational Physics Course**

*Contributed – Walter Freeman, Syracuse University, 215 Physics Building, Syracuse, NY 13244; wafreema@syr.edu*

Computational physics is an interdisciplinary field, in which computer science, numerical methods, data analysis, and the laws of physics come together to create insights about the physical world. Guided by Hamming's aphorism that "the purpose of computation is insight, not numbers," the only graded item in my computational physics course is a series of project reports. The students aren't just asked to write code that simulates something; they have to write a long-form report describing how this simulation led to insight about physics or mathematics. This both guides students along the path to interdisciplinary synthesis of knowledge into a unified whole, and gives me a far better picture of how well the students understand the material.

### **Session FN(A): Technologies**

**Location:** Meeting Room 4    **Sponsor:** AAPT    **Time:** 5–5:50 p.m.    **Date:** Tuesday, July 31    **President:** Shahida Dar

### **FN(A)01: 5:00-5:10 p.m. Technology in the Classroom: Second Order Effects**

*Contributed – Tatiana Stantcheva, Northern Virginia Community College, 5000 Dawes Ave., Alexandria, VA 22311; tstantcheva@nvcc.edu*

The classroom at a community college is arguably the most diverse of all. At any given day, an instructor will find students ranging from inexperienced high-schoolers to career professionals with advanced degrees. Different socio-economic and cultural backgrounds further contribute to tangible rifts within the classroom. While technology has already been used in the classroom to elucidate hard concepts, to help engagement, and generally to enhance the classroom experience, in certain occasions it can actually subtly undermine students of low income or those lacking technical non-physics related skills. In this talk, I will give examples of how one and the same technology can be used to further divide students or to bring them together. I will also include what I have used in the introductory physics course to help students overcome possible difficulties due to technical or financial situations, and help them demonstrate their true academic potential.

### **FN(A)02: 5:10-5:20 p.m. Students' Views and Expectations about Web-based Computer Coaches**

*Contributed – Bijaya Aryal, University of Minnesota-Rochester, 111 S Broadway, Suite#300, Rochester, MN 55904; baryal@r.umn.edu*

We adopted web-based computer coaches as an innovative approach to facilitate physics problem solving. Our prior studies have shown positive impacts of the tool on students' problem solving performance. To explore ways to enhance efficacy of the tool, we conducted in-depth interviews of 19 students who had used the coaches as part of their homework in a physics course. Qualitative data analysis has provided insights about the usefulness and the shortcomings of the software and pedagogical frameworks of the coaches. Participant students generally considered the tool as user-friendly, easy to use, and non-intimidating. This study has identified that implementation challenges emerge primarily due to students' expectations about coaching, learning, problem solving, learning resources and time of task. Other factors that impact adoption of the tool include: flexibility of the tool and students' academic confidences. This presentation will describe these challenges and recommend possible solutions for successful implementation of the system.

### **FN(A)03: 5:20-5:30 p.m. Designing for a 3d Printer**

*Contributed – Paul E. Noel, Yale University, 217 Prospect St., New Haven, CT 06510; paul.noel@yale.edu*

Access to 3D printers has increased rapidly over the past few years. Their usefulness in rapid construction and prototyping of lab, demo, and outreach equipment is extraordinary. However, when it is best to 3D print? If 3D printing is warranted, what design rules should we follow? What are the common design mistakes? What elements should we include to improve the quality and durability of our print. To illustrate these points concretely, we will use the design, print, and construction of a 4-Point Probe apparatus, beginning from the initial decision tree for the manufacturing parameters through choices for tolerance, accuracy, strength, material, warping, and joinery. We may also cover some specific topics such as: supports, fillets, wall thickness, overhang, surface details, bridging, holes, and finishing. We will also give you useful guidelines and some generally applicable rules that will improve your design and increase the likelihood of a successful 3D print.

### **FN(A)04: 5:30-5:40 p.m. Using Arduino Uno Microcontroller to Create Interest in Physics**

*Contributed – Amtul Mujeeb Chaudry, University of La Verne, 1950 Third St., Laverne, CA 91750; achaudry@laverne.edu*

Use of microcontrollers is becoming increasingly popular in the lower division physics classroom. This approach can be utilized to create interest among students through hands-on learning of physics concepts. The arduino uno microcontrollers were used as an extra credit exercise to create interest in algebra-based undergraduate physics courses. Some of the simple yet interesting outcomes of student work, as well as their feedback about this activity are presented here.

### **FN(A)05: 5:40-5:50 p.m. The Foucault's Pendulum: Exploration Using MAPLE18**

*Contributed – Shyamkant Wasudeorao Anwane, Shri Shivaji Science College, Congress Nagar, Nagpur, India 440012 India swanwane2000@yahoo.com*

*Yashwant S. Anwane, Shri Shivaji Science College*

In this article, we develop the traditional differential equation for Foucault's Pendulum from physical situation and solve it from standard form. The sublimation of boundary condition eliminates the constants and choice of the local parameters (latitude, pendulum specifications) offers an equation that can be used for a plot followed by animation using MAPLE. The fundamental conceptual components involved in preparing differential equation viz; (i) rotating coordinate system, (ii) rotation of plane of oscillation and its dependence on latitude, (iii) effective gravity with latitude are discussed in detail. The accurate calculations offers quantities up to sixth decimal point are used for plotting and the animation purpose. This study offers delightful hands-on experience. Optimised suitable quantities for readers latitude can lead a way to build a project of miniature model of the pendulum.

## Session FN(B): Using Jupyter Notebooks to Analyze Big Science Data Sets

**Location:** Meeting Room 4    **Sponsor:** Committee on Modern Physics    **Co-Sponsor:** Committee on Physics in High Schools    **Time:** 6–7 p.m.  
**Date:** Tuesday, July 31    **President:** Joel Klammer

### FN(B)01: 6:00-6:30 p.m. Teaching 6-12 Science Content with Coding and Data Visualization

*Invited – Adam LaMee, University of Central Florida, 517 London Rd., Winter Park, FL 32792; adamlamee@gmail.com*

Equal access to lucrative careers depends on every student being exposed to coding. However, a dedicated computer science course is not the answer for all, or even most, students. Science courses are prime territory for this task. Find out how two large school districts in Florida are making that happen. Teachers have enough to cover without adding computer programming to the list. Our approach is to use it as a tool for addressing science content standards -- the coding is secondary. Though you won't see loops and conditionals taught explicitly, this allows non-CS-fluent teachers to use these activities without extensive training. You'll learn how to analyze amazing data from CERN, USGS, & NASA using Python, Pandas, & Jupyter. And the resources are free and easily editable for your own course objectives. We'll also discuss implementation options from standalone installs to server-level solutions with Jupyterhub and Binder. Details at [www.adamlamee.com](http://www.adamlamee.com)

### FN(B)02: 6:30-7:00 p.m. Writing Code in the Physics & Astronomy Classroom

*Invited – Jeremy R. Smith, Hereford High School, 17301 York Rd., Parkton, MD 21120; jsmith10@bcps.org*

Nearly every physicist in the world writes and/or modifies computer programs. In recent years, code-writing has become an essential skill for nearly all the other science disciplines as well. Therefore, physics teachers can play a vital role in helping students to learn this skill in the context of scientific problem solving. Jupyter notebooks are a relatively easy way for students to get some practice writing code: by seeing the framework of the language in the notebook, but having to make adaptations and additions to suit their own needs, students can achieve quite a lot at this "Goldilocks" level of code-writing. In this workshop you'll see examples of how this sort of thing could be implemented in a typical first-year physics or astronomy classroom. A key idea is that this can run parallel to your already-existing lessons, reducing the amount of extra class time needed to make it work.

## Session TOP04: Topical Discussion: Solo PER

**Location:** Meeting Room 10/11    **Sponsor:** Committee on Professional Concerns    **Co-Sponsor:** Committee on Physics in Two-Year Colleges    **Time:** 5–6 p.m.  
**Date:** Tuesday, July 31    **President:** Steve Maier

*Are you the only professional active in PER within your department? Are there only one or two colleagues in close proximity you can talk "PER shop" with? The membership of Solo PER is larger than you may think, and more diverse than most suspect. Join us for this topical discussion to connect with other Solo PER professionals and learn what is being done to help our/your endeavors. As in the past, bring questions, ideas and professional concerns to share. Consider joining the Solo PER group at PERcentral ahead of the meeting for occasional updates!*

## Awards Session: Klopsteg Memorial Lecture Award to Clifford V. Johnson

Location: Renaissance Ballroom

Sponsor: AAPT

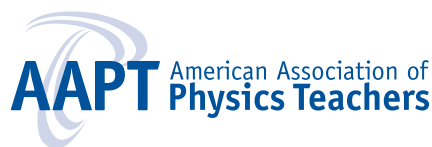
Time: 8:30–9:30 a.m.

Date: Wednesday, August 1

President: George A. Amann



**Clifford V. Johnson**  
University of Southern  
California, Los Angeles



## Black Holes and Time Travel in Your Everyday Life

A little over a hundred years ago, Einstein helped us rethink space and time, and shook our conception of the universe to its foundations. Concepts like black holes, warped spacetime, wormholes, the multi-universe, and time travel solidified and entered discussions of both our real universe and the universe of our imaginations. I'll talk about some of these ideas, including aspects of exciting current research into them, and I'll also talk about the role of these concepts in popular culture, describing my work helping creators to interweave these concepts into their storytelling in blockbuster movies, primetime TV, and bestselling books.

### Session PST2: Poster Session 2

Location: Grand Ballroom South

Sponsor: AAPT

Time: 9:30–11 a.m.

Date: Wednesday, August 31

Persons with odd-numbered posters will present their posters from 9:30 to 10:15 a.m.; those with even-numbered posters will present from 10:15 to 11 a.m. Posters will be available until 12 noon.

## Lecture/Classroom

### PST2A01: 9:30-10:15 a.m. Method of Solving Time Problems in Harmonic Oscillator

Poster – Quy Hong Pham, Yersin University of Da Lat, 01 Ton That Tung, Da Lat, Lam Dong 670000 Viet Nam phamhongquy@gmail.com

Time is an important factor in solving physics problems. In the General Physics program for K12 students, the harmonic oscillator occupies a large part of the mechanical oscillator, the mechanical wave and the alternating current. Incorporating the trigonometric ring into the calculation of time factors will help students understand the concept of oscillator much better and easier. Through this article, I would like to introduce some simple but effective methods for physics learners to understand problems of harmonic oscillation most easily.

### PST2A02: 10:15-11:00 a.m. Practical Sigma/Delta Relation for Teaching Single-Slit Diffraction Uncertainty Principle

Poster – Richard A. Zajac, Kansas State Polytechnic, 2310 Centennial Road, Salina, KS 67401-8196; rzajac@ksu.edu

Illustration of the Heisenberg Uncertainty Principle in terms of single slit particle diffraction is common in introductory texts. Such a presentation is conceptually and qualitatively useful, but is often confusing for students to apply numerically due in part to the differing interpretations of sigma and Delta presented in different texts and online resources, along with apparently differing definitions of the Uncertainty Principle. A simple scheme is presented to disambiguate and apply these terms numerically. This scheme has been successfully used by students in the Alg/Trig-based introductory course with good accuracy, without the need to substitute alternative results from a “more rigorous” treatment, as is common in several texts.

### PST2A03: 9:30-10:15 a.m. Project Yellow Light: Physics and Social Issues in Chicago

Poster – Johan Tabora, Northside College Prep HS/University of Illinois at Chicago, 5501 N Kedzie Ave., Chicago, IL 60625; jntabora@cps.edu

This poster explains a culminating kinematics project in a 9th-grade physics course at a public high school. The project problematizes the physics implications of Chicago's 3-second yellow light and uses the socio-scientific issues framework to empower students to make complex decisions at the interface of science, technology, and society. Furthermore, the project hopes to develop science agency where students use their scientific knowledge to enact change in themselves and their environment. Students use kinematics concepts to evaluate the 3-second light time and use their findings to explore the related socio-political issues. Examples of issues are the locations of Chicago's red-light traffic violations, Illinois' income tax structure, and other city-levied fees and taxes.

### PST2A05: 9:30-10:15 a.m. Role of Characteristics of Bodies in Newton's Third Law of Motion

Poster – Ajay Kumar Sharma, Fundamental PHYSICS Society, His Mercy Enclave, Post Box 107, GPO Shimla, HP 171001 India ajoy.plus@gmail.com

The third law establishes universal equality between action and reaction. The law is practically expressed in terms of forces. In third application of third law at page 20 of the Principia, Newton stated, “If a body impinges upon another and by its force change the motion of the other, that body also will undergo an equal change, in its own motion, towards the contrary part. Mathematically forward velocity of target,  $V_{\text{forward}} = (U_{\text{forward}} - U_{\text{backward}}) m/M$  If target is heavier and remains at

rest e.g. a ball impinges a heavy body then  $V_{\text{forward}}=0$ ,  $U_{\text{forward}}=U_{\text{backward}}$  or projectile must rebound with initial velocity. In this case characteristics, nature, compositions of bodies ( steel , rubber , spring , chewing gum) are practically and experimentally significant. These can be taken in account if law is generalised i.e. reaction is proportional to action through coefficient of proportionality.

**PST2A06: 10:15-11:00 a.m. Sparking Interest in STEM**

Poster – Kathleen VanBaren, *Onteora Central School District, 4166 State Route 28, Boiceville, NY 12412; kate.vanbaren2@gmail.com*

According to a 2012 article in *International Journal of Environmental & Science Education*, “Students are making choices in middle school that will impact their desire and ability to pursue STEM careers. Providing middle school students with accurate information about STEM (Science, Technology, Engineering, Mathematics) careers enables them to make more knowledgeable choices about courses of study and career paths” (Vanessa L., Heulskamp, & Siebert, 2012). In order to give all middle school students in our school an opportunity to learn more about STEM fields, activities involving robotics, computer programming, and electronics have been integrated into the eighth grade general science course. The poster provides examples of these projects over the last few years.

**PST2A07: 9:30-10:15 a.m. Special Relativity as Part of the First-Year Introductory Physics Course**

Poster – Alice D. Churukian, *The University of North Carolina at Chapel Hill, CB:3255 Phillips Hall, Department of Physics and Astronomy, Chapel Hill, NC 27517-3255; adchuruk@physics.unc.edu*

Reyco Henning, Stefan A. Jeglinski, Duane L. Deardorff, *The University of North Carolina at Chapel Hill*

At the University of North Carolina at Chapel Hill, we have incorporated a unit on Special Relativity into our first semester introductory physics course required for students of the physical sciences (chemistry, math, computer science, applied science, and physics majors). The course is taught in a lecture/studio format where students attend a 1-hour lecture and a 2-hour studio twice per week. Students spend two and a half weeks studying everything from simultaneity to relativistic momentum, focusing primarily on conceptual understanding through the use of space-time (Minkowski) diagrams. We will present a sample of the materials used in both lecture and studio, insights into the challenges of introducing Special Relativity at the introductory level, and comments from students enrolled in the course.

**PST2A08: 10:15-11:00 a.m. Standards-based Grading: Assessing the Assessment**

Poster – Katrina E. Black, *Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931-1295; keblack@mtu.edu*

In standards-based grading systems, student grades are based on mastery of course objectives rather than a percentage of points earned on each particular assessment. Since spring 2017, I have used standards-based grading in an algebra-based introductory physics sequence for technology majors. I reflect on three semesters of standards-based grading, including how the grading scheme has evolved, practical considerations for choosing assessment questions and recording grades, and student responses to the system.

**PST2A09: 9:30-10:15 a.m. Student Perspectives about Active Learning in German Physics Lectures**

Poster – Cynthia E. Heiner, *Freie University Berlin, Arnimallee 14, Berlin, 14195 Germany cynthia.heiner@fu-berlin.de*

Research indicates that students learn more in an interactive learning environment. Yet despite the increasing empirical evidence, the active teaching and learning techniques are rarely tried in German higher education institutions. I report here on German students’ opinions towards pre-class online assignments (‘Just in Time Teaching’) and in-class Peer Instruction via clickers in an introductory mathematical physics class. Furthermore, I will discuss the cultural differences in the education systems as well as how best to encourage students to engage with active learning in Germany.

**PST2A10: 10:15-11:00 a.m. Teaching Strategies for Calculus Review in Introductory Physics**

Poster – J.C. Yoon, *University of Guam, UOG Station, Mangilao, GU 96923; jcyoon@yahoo.com*

The concept of calculus is briefly summarized with physics examples in the first lecture of introductory physics. The most topics in limits and continuity is avoided, and one simple point is emphasized that most functions in nature and in physics course are continuous and differentiable. The differentiation of function is roughly translated as slope, that is, rise over run, to find out the change of output compared to that of input, but it is presented with functional format instead of x, y coordinates. And it is demonstrated with linear and parabola functions with numbers. Using an example of speed, the integration of motion is introduced as summation of the change of distance per unit time, which is often overlooked as we consider integration as area only. A couple of Riemann sum with linear functions are used to demonstrate how the integration works.

**PST2A11: 9:30-10:15 a.m. Teaching Strategies for Dynamics in Introductory Physics**

Poster – J.C. Yoon, *University of Guam, UOG Station, Mangilao, GU 96923; jcyoon@yahoo.com*

Learning dynamics in introductory physics, students have difficulty in building connection between kinematics and dynamics and identifying the objects associate with force due to the ambiguity of force notation. The concept of applying force is introduced earlier in kinematics and the motion of an object is consistently analyzed and connected to net force using inquiries with plain English. As a common practice of omitting the roles of objects in force notation for simplicity causes trouble in free-body diagrams and Newton’s laws of motion, every force in the lecture is labeled by which object force applies and on which object the force applies at a cost of elegant notation. Also, as many students find it difficult to come up what forces should be considered in a free body diagram, a list of possible forces is presented for them to check out and select the appropriate forces.

**PST2A12: 10:15-11:00 a.m. Teaching Strategies for Trigonometry Review in Introductory Physics**

Poster – J.C. Yoon, *University of Guam, UOG Station, Mangilao, GU 96923; jcyoon@yahoo.com*

For introductory physics, trigonometry is reviewed in the first lecture to establish the understanding of trigonometry on the basic concepts of physics with one main techniques of trigonometric identities. Using an example of physics application, the concept and purpose of trigonometric function are redefined with physically meaningful interpretations. In many physics applications in the following lectures, these interpretations make the students consider the purpose of trigonometric functions in selecting the appropriate functions, instead of using mathematical definition of trigonometric functions as a routine. Also, one set of rules in trigonometric identities is selected and used for the whole course to make it more effective and faster in dealing with physics applications.

**PST2A13: 9:30-10:15 a.m. Teaching Strategies of Kinematics in Introductory Physics**

Poster – J.C. Yoon, University of Guam, UOG Station, Mangilao, GU 96923; jcyoon@yahoo.com

Teaching introductory physics to students with minimal experience of physics classes in secondary schools, the class curriculum for kinematics in the lecture has been modified to effectively cover the contents from the basics of kinematics including lab activities. The motion of an object is consistently presented with a motion diagram with inquiries on position, velocity, acceleration, and net force using plain English and the concepts of calculus. The motion diagram is investigated with a table to record the data and they are plotted in terms of time. Since students struggle with the plots for these physical quantities that are presented individually or at random order in the lectures or tests, the plots of position, velocity, and acceleration are always presented in the same order as a set in the lecture and assignments. The plots are analyzed with slope in differentiation format and area using a simple Riemann sum.

**PST2A14: 10:15-11:00 a.m. The Process of Learning and Assessment in Activity-based Physics Classrooms**

Poster – Yuehai Yang, Oregon Institute of Technology, 3201 Campus Dr., Klamath Falls, OR 91360; yuehai.yang@oit.edu

David Kirkendall, Oregon Institute of Technology

Suman Neupane, Middle Tennessee State University

David Brookes, California State University, Chico

Multiple assessment instruments have been implemented in an activity-based physics course at Oregon Institute of Technology. In and outside of the classroom, students work together on a variety of learning activities with the assistance from supplemental instructors and are offered ample opportunities to participate in this active learning process. Assessment data are collected through Gradescope, an AI assisted grading tool, as well as traditional surveys. The result of this analysis is useful to identify important impact factors which contribute to student success in reformed introductory physics courses.

**PST2A15: 9:30-10:15 a.m. The Triplets Paradox. About Acceleration in Special Relativity**

Poster – Martín Monteiro, Universidad ORT Uruguay, Aconcagua 5152, Montevideo, 7 11400 Uruguay; fisica.martin@gmail.com

In this work a didactical approach about the well known twins paradox is discussed. In a simple and visual way it is shown that two systems could go through the same accelerations and yet end up having different times at the end of their trips, pointing out that the amount of acceleration is not the key of the problem. The change of inertial reference frame is highlighted to understand the issue together with the role of acceleration in special relativity and the twin paradox in particular.

**PST2A16: 10:15-11:00 a.m. Using Social Deduction Games to Help Understand Physical Concepts**

Poster – Matt Olmstead, King's College, 133 North River St., Wilkes Barre, PA 18711; matthewolmstead@kings.edu

As part of our physics senior seminar course, the students are doing an in-depth research project in which they focus on one area of physics that has not been discussed in their previous courses and have several different projects based off of this including a paper, presentation, and poster. There are additional smaller assignments, one of which includes adding a scientist from their project into a social deduction game. In the game, each student is initially given a secret role; some are good and some are bad. During the course of the game, each role does one thing: swapping roles, looking at another role, getting a new role, etc. At the end, a vote is performed to see if one of the bad characters can be identified. This game has been modified to include the scientists from their projects and figuring out what sort of abilities fit these characters.

**PST2A17: 9:30-10:15 a.m. What Bad Puzzles Teach Us About Good Science**

Poster – David L. Morgan, Richard Bland College, Richard Bland College, 11301 Johnson Rd., Petersburg, VA 23805; dmorgan@rbc.edu

Nowadays it's common to encounter "logic" puzzles online that pose as mathematical exercises, and frequently Internet commenters will argue over the right answer for days or weeks at a time. Often it is because these puzzles are, in fact poorly-designed as mathematical statements, and the "right answer" is ambiguous at best. But while they may fail as math problems, they succeed as examples of inductive reasoning in the sciences, and underscore the fact that scientific theories are always "underdetermined" by the available data. This poster gives an example of one such puzzle, along with suggestions for classroom discussions on topics such as theory construction, theory testing, underdetermination, simplicity, and falsification.

**PST2A18: 10:15-11:00 a.m. A Curriculum to Address Under-Representation and Culture in Physics**

Poster – Moses Rifkin, University Prep, 8000 25th Ave NE, Seattle, WA 98115 mrefkin@universityprep.org

Chris Gosling, McGill University

Dana Hsi,

Motivated by our shared desire to address under-representation in physics, we have created a flexible, modular curriculum designed to help physics teachers bring conversations about science and society into our classrooms. In this session, we will preview the curriculum, share preliminary data demonstrating its influence, and reflect on our experiences. Attendees will have an opportunity to download curricular resources, and will learn how to join our working group going forward. Together, we offer students and teachers a guided means to consider the culture of physics in order to create a more welcoming community.

**PST2A19: 9:30-10:15 a.m. A First-Year Experience Program in Physics**

Poster – John H. Simonetti, \* Virginia Tech, Physics Department, Blacksburg, VA 24061; jhs@vt.edu

Alma Robinson, Kasey L. Richardson, Shadisadat Esmaeili, Virginia Tech

Courtney Vengrin, Iowa State

First-year physics majors at Virginia Tech take the introductory calculus-based sequence, taught with a student-centered approach, in a SCALE-UP classroom. In addition, our program includes a parallel sequence designed to enlarge the students' view of physics beyond the introductory curriculum and give them the skills they need to succeed as undergraduate physics majors, and beyond. This additional course sequence, also taught in a SCALE-UP classroom, is called "Thinking Like a Physicist," and includes explicit work on solving Fermi problems and other open-ended, ill-defined problems. They also learn systematic procedures for solving "end-of-chapter" problems, selected concepts in calculus, and numerical computations. Other topics investigated include research in the department and career paths. We will present our results from pre- and post-testing using various instruments including the Force Concept Inventory, Conceptual Survey in Electricity and Magnetism, and the Colorado Learning Attitudes about Science Survey.

\*Sponsored by Alma Robinson



**PST2A20: 10:15-11:00 a.m. Acceleration-centered Physics: Sharp Departure from the Traditional Free-Body-Diagram**

Poster – John R. Walkup, Fresno State University, 2345 E. San Ramon Ave., M/S MH37, Fresno, CA 93740; jwalkup@csufresno.edu

Traditional problem-solving in physics involves students following a step-wise method where they create a free-body diagram and then attempt to solve the problem by examining known and unknown variables. The cognitive gap to the next step, formulating equations that govern the forces and motion encountered in the problem, is large and daunting, often leaving students grasping for any equations they can find that incorporate a matching set of known and unknown variables. The author has reformulated the traditional problem-solving method by elevating the acceleration as a gateway between cause, described by Newton's laws, and effect, described by equations of motion. (In essence, the acceleration in mechanics is regarded in much the same way as the state vector in quantum mechanics.) Such an approach has the advantage of providing students with a path toward successful completion of the entire problem from start to finish. It also highlights the Deterministic relationship between cause and effect. Finally, this approach is robust, being applicable to every (or nearly every) Newtonian force problem likely to be encountered by introductory physics students. In this poster, the author will present this new problem-solving scheme, then show how it applies to linear acceleration, centripetal acceleration, and angular acceleration problems with relative ease.

**PST2A21: 9:30-10:15 a.m. Active and Engaged Learning: Lessons from the Rookie Semester**

Poster – Toni Sauncy, Texas Lutheran University, 1000 West Court St., Seguin, TX 78155; tsauncy@tlu.edu

The introductory calculus-based physics course at Texas Lutheran University has been transformed from an “active” learning “traditional” format into a hybrid-inverted learning environment through the use of web-based video and simulation tools. Reluctance to change the format of the course quickly became enthusiasm as the potential for learning (by the instructor) became apparent. Lessons from this first time modified flipper, along with the student response to the revised pedagogy will be discussed.

**PST2A22: 10:15-11:00 a.m. An Inquiry-based Biophysics Course for Non-majors**

Poster – Christina Othon, Ripon College, 300 West Seward St., Ripon, WI 54971; othonc@ripon.edu

The development of a college-wide, general education curriculum alleviated pressure to offer 100-level introductory physics courses for non-majors. This opened the opportunity for us to reconsider the type general education courses most needed to serve other disciplines at the institution. Ripon College has a large number of elementary and secondary education, health pre-professional, exercise science, and pre-engineering students. We developed an inquiry-based learning course that had no prerequisites that could satisfy the physical education needs of our education majors while providing a soft entry into the physics curriculum for our health pre-professionals. The course emphasizes hands-on activities that build quantitative reasoning skills and promotes a firm understanding of matter and physical properties of biomaterials. The course is populated by students of a wide mathematical and scientific background. We present results regarding the value of the course content for the target student populations.

**PST2A23: 9:30-10:15 a.m. An Integrated Career-Development Curriculum for College Physics Majors**

Poster – Joshua M. Grossman, St. Mary's College of Maryland, 46745 College Drive, St. Mary's City, MD 20686; jmgrossman@smcm.edu

Erin K. De Pree St. Mary's College of Maryland

We present a curriculum in which college physics students engage in career exploration and perform activities to develop skills for career advancement. We embed the curriculum in conventional physics courses, plus special program-wide events. This emphasizes the central importance of these skills for students and requires all students to develop these skills. While some material draws from the Careers Toolbox for Undergraduate Physics Students, developed by the American Institute of Physics and the Society of Physics Students, our curriculum is significantly more expansive, covering more career phases, plus including additional skills and activities. The Phys21: Preparing Physics Students for 21st Century Careers report by AAPT and the American Physical Society touched on this curriculum in its case study of best practices in our department. Besides providing more details on the curricular content, we will also present impacts from its implementation.

**PST2A24: 10:15-11:00 a.m. Assessing Understanding Using Student-Created Video Tutorials**

Poster – Bradley F. Gearhart, Buffalo Public Schools, 1982 Stony Point Rd., Grand Island, NY 14072; fizz6guy@yahoo.com

Most high school students carry in their pockets a powerful tool for learning and assessment. Today's smartphones and tablets allow students to explore and generate content in ways that were impossible just a decade ago. Fortunately, many schools are now embracing this new tool for expression and consumption and looking for new and creative ways to engage and assess student understanding. This poster will explore my use of student-created video tutorials for assessing their understanding of forces. Students record everyday scenarios and then create a tutorial video applying concepts and tools developed in class to describe and explain their everyday occurrence.

**PST2A25: 9:30-10:15 a.m. Complete Introductory Physics Courses Online**

Poster – Byron Drury, MIT, Room 26-331, Cambridge, MA 02139-4307; bdrury@mit.edu

David E. Pritchard, Isaac Chuang, MIT

Zhongzhou Chen, University of Central Florida

Evidence suggests that blending online and on-land teaching in some sort of flipped classroom results in more learning than either extreme. Unfortunately, optimally combining online, in-class, weekly homework and quizzes, and on-paper activities presents a formidable and time-consuming organizational challenge for the instructor. We are assembling sets of these resources into complete courses for intro mechanics and E&M at both algebra- and calculus-based levels. These can be flexibly assigned in the open-source online platform - edX.org. Importantly, student interaction data are recorded in BigQuery; we extract problem difficulty and time on each resource, and can improve the course through research. These courses will be available as Customizable Courses this fall, and possibly in Canvas. Ultimately we will use the Harvard DART system to allow teachers to assemble courses from a library with descriptive and performance metadata about each resource. Volunteers are solicited for beta-testing and for curating existing resources.

**PST2A27: 9:30-10:15 a.m. How Are the Women Scientists Academic Trajectories?**

Poster – Isabelle Priscila Carneiro De Lima, Federal University of Bahia, Brazil Avenida Cardeal da Silva, 213 Salvador, Bahia 40231305 Brazil isapris@gmail.com

It is usual in physics classes the use of historical approaches to highlight the participation of important men. However, in Brazil, there are few studies about women's role and trajectory in physics. To join teaching, history of physics and the participation of women in science, we promoted a debate to thinking about 'how are the

women scientist's academic trajectories?' To this, we presented Lise Meitner's trajectory, as an example. We highlighted important aspects of her life that helped us to start discussions with high school students. Then, to this presentation, we will report how this activity happened, what were the student's feelings and opinions before, during and after activity. We found students recognized similarities among women scientist's carriers, whether they are researchers, teachers or professionals in the technical area. It was possible to think over the barriers in our carriers and encourage students to think they could be a scientist.

Women in Physics - Lise Meitner - women scientists trajectories

### **PST2A28: 10:15-11:00 a.m. Interpreting and Solving Problems Using Inequalities**

Poster – Jonathan Bennett, North Carolina School of Science and Mathematics, 1219 Broad St., Durham, NC 27705; bennett@ncssm.edu

"Inequality problems," in which a physical quantity (such as a static friction force) can assume a range of possible values, provide interesting and instructive opportunities for students to practice problem-solving skills. Standard textbook approaches to solving such problems tend to examine only limiting cases (for example, the situation where the static friction force has reached its maximum possible value). We consider several common introductory problems and illustrate how a more general approach to solving inequality problems leads to more complete, interesting and instructive solutions, while only modestly increasing the mathematical complexity of the analysis.

## **Other Posters**

### **PST2B01: 9:30-10:15 a.m. Physics to Visually Impaired Children: A Brazilian Experience**

Poster – Isabelle Priscila Carneiro De Lima, Federal University of Bahia, Brazil, Avenida Cardeal da Silva, 213 Salvador, Bahia 40231305 Brazil; isapris@gmail.com

Luzia Mota, Beatriz Velame, Josileide Oliveira, Roseane Santos, Federal Institute of Bahia, Brazil

One of the challenges in physics teaching is to find ways to present physics to visually impaired people. We are working on a project that intends to bring science to visually impaired children, specifically focusing on ideas about light. A part of this project was developed in the National Week of Science and Technology, an annual event that happens in Brazil. In this presentation, we will report this experience. Based on studies and in other projects, we developed activities on how a rainbow occurs. For this, we presented a video with an audio description about the explanation for the rainbow; after that, the children built a tactile prototype of the decomposition of light; finally, we did a storytelling session of the important scientist's life. We noticed the children's interest and curiosity during this variety of activities. Besides, it was possible to teach physics to visually impaired children with this approach.

Physics to children - visually impaired - Light

### **PST2B02: 10:15-11:00 a.m. Research Opportunities for Underrepresented Students in Earth & Space Sciences\***

Poster – Prabhakar Misra, Howard University, Department of Physics & Astronomy, Washington, DC 20059; pmisra@howard.edu

Susan Hoban, Belay Demoz, University of Maryland Baltimore County

Blanche W. Meeson, William M. Farrell, NASA Goddard Space Flight Center

This early opportunities research program is funded under the auspices of the NASA Minority University Research and Education Other Opportunities Project (MUREP) and is a partnership between Howard University, University of Maryland Baltimore County and NASA Goddard Space Flight Center. It engages underrepresented STEM students in cutting-edge Earth & Space Science-focused research under the mentorship of seasoned NASA researchers throughout the academic year, and a full-time 10-week research internship during the summer at NASA Goddard. Since its inception in August 2016, the project has benefited 12 early career Howard University undergraduate STEM students.

\*Financial support from MUREP NASA Award Number NNX16AC90A is gratefully acknowledged.

### **PST2B04: 10:15-11:00 a.m. Stratospheric Temperature Changes Observed During the 8/21/2017 Total Solar Eclipse**

Poster – Erick Agrimson, St. Catherine University, 2004 Randolph Ave, #4105, Saint Paul, MN 55105; epagrimson@stkate.edu

Kaye Smith, St. Catherine University

Gordon McIntosh, University of Minnesota, Morris

James Flaten, University of Minnesota, Twin Cities

We present additional results related to stratospheric temperature measurements taken before and during the August 21st, 2017 total solar eclipse. St. Catherine University and the University of Minnesota, Morris, collected data from six high-altitude balloons (HABs) launched during the two days prior to the eclipse and on the eclipse day. The overall atmospheric changes between pre and eclipse day flights were significant; an observed cooling of over 10 degrees Celsius in the stratosphere. We also observed a measurable change in temperature at the tropopause boundary. Temperature measurements were collected via a "wake boom" a structure, which characterizes the magnitude and extent of the thermal wake below an ascending balloon using over 20 temperature sensors, set at intervals along a horizontal carbon fiber rod.

### **PST2B05: 9:30-10:15 a.m. The Effects of the Length of Junctions Between Balls**

Poster – Hao Xin Sun, No.2 Dongnandaxue Road, Nanjing, Jiangning 211100 958664094@qq.com

If a chain initially rests in a container above the ground and pulled over the rim of the container, the top of the chain will rise up above the container, which is called a "chain fountain." Since researchers did not include the effects of junctions between balls, former models fail to predict the experimental results when using chains with balls in different shapes. In our experiments, the relation between the steady-state chain height and the length of junctions of the chain is analyzed experimentally and theoretically. Data is collected by using chains with junctions of different lengths while their other physical parameters are constant during experiments. Meanwhile, the weight of junctions is relatively small compared with the whole chain, so its impact is neglected during our analysis. We map the Height-Length of Junctions diagram and the measurements for different chains coincide with our theoretical analysis.

### **PST2B06: 10:15-11:00 a.m. Women's Leadership in Physics Education**

Poster – Laura McCullough, University of Wisconsin-Stout, 327 12th Ave. W, Menomonie, WI 54751-2434; lauramccphd@gmail.com

When people discuss the representation of women in physics, we often focus on enrollments and degrees. This data is readily available and is important to our discussion. We rarely talk about leadership positions in physics and women's participation in these roles. In this talk I will share data about the numbers of women

in various leadership positions in physics education: editors, research group directors, professional organization roles. This data is more difficult to gather because of the short-term nature of people's time in these roles. But a snapshot in time of this data provides important information for the discussion of under-representation in physics.

**PST2B07: 9:30-10:15 a.m. Doing Research with Undergraduates in a Bachelor's-only Physics and Astronomy Department**

Poster— *Matthew R. Semak, University of Northern Colorado, Department of Physics and Astronomy, Campus Box 127, Greeley, CO 80639; matthew.semak@unco.edu*  
*Cynthia Galovich, Richard Dietz, University of Northern Colorado*

For many disciplines, it appears that the number of undergraduates involved in research is increasing. One can certainly argue that this is true for physics and astronomy. This is encouraging given the range of benefits students gain from such an experience. At the University of Northern Colorado, we have been fortunate to have undergraduate research as a component of the program for over 30 years. However, many students are overcome by classwork and do not see research as a viable option during their undergraduate career. Indeed, some are weary of approaching such a challenge given their limited experience with such a process. Moreover, without the extensive research efforts, facilities, graduate student mentors, and other important resources associated with graduate institutions, can an undergraduate program provide a meaningful research experience for its students? Indeed, the lack of funding devoted to student projects and the often-limited external collaborations can have students wondering about opportunities of which they were not aware. They also ask if they have been given the full range of tools for current and future success. These are frequent questions. We would like to present some possible answers by telling you about some of the journeys in research we, along with our colleagues, have taken with our undergraduates. With persistent attention to the evolving needs of our students along with an understanding of our advantages and limitations, we believe our program has substantial positive outcomes to report.

**PST2B08: 10:15-11:00 a.m. Further Research on the Spring Pendulum**

Poster — *Yan Huang, Southeast University, No.2Dongnandaxue Road, Jiangning District, Nanjing, China 210000 China wxhuangy@sina.cn*  
*Hua Yuan, Ze Hua Tang, Southeast University*

When a pivot of a spring pendulum starts moving along a horizontal circumference, the movements of the bob attached to the spring exhibit different patterns. We use difference method to do theoretical analysis concerning length and movement of the spring, and our numerical results correspond with that. In the low angular velocity regime, the dynamic system of the spring pendulum shows various bifurcations. When the stiffness coefficient becomes larger than a certain degree, the system turns into chaos.

**PST2B09: 9:30-10:15 a.m. Latent Colonialism and Exclusionary Culture**

Poster — *Danny Doucette, University of Pittsburgh, 504 Coal St., Pittsburgh, PA 15221; danny.doucette@pitt.edu*

Although physics is a practice and body of knowledge that has historically drawn on people and cultures from around the world, many of our words and symbols today belie this reality. Instead, our field has lionized the work of white Western men while adopting, without fairly crediting, contributions from across the world and through time. In this sense, we might think of contemporary physics instruction as a colonial enterprise. Problematically, some of our language and signifiers send messages that may be responsible for perpetuating negative experiences and stereotypes that result in inequities and poor diversity in our field. This poster will dissect examples; propose modes of talking, teaching, and doing physics that move beyond colonial norms; and present ways we could use a critical approach to the history of physics as a tool to inspire positive growth in physics culture.

**PST2B10: 10:15-11:00 a.m. Nonlinear Analysis of a Popsicle Stick Bomb**

Poster — *Chengzhi Cai, No.2 Dongnandaxue Road jiangning District, Nanjing, jiangning 211100 970489129@qq.com*

A large potential energy can be released when weaving the stick bomb. However, in the experiment of the popsicle stick bomb, we find that repetitive experiments lead to a great uncertainty in measurement. It is because that when stress exceeds the threshold, popsicle sticks experience yield phenomenon which means plastic deformation and disability of returning to the original state. In this case the pattern of stress and strain is a nonlinear function. The experiment explores the law of nonlinear variation in the popsicle stick bomb. The experimental data is measured by using popsicle sticks with different sizes and different materials. Meanwhile, we use the same group of sticks in a series of experiments. The deformations of the sticks ranges from big values to small values. We also map the Stress-Strain diagram. Finally, we get the range of linear variation and the rule of nonlinear variation. Materials also impact results.

**PST2B11: 9:30-10:15 a.m. OER Learning and Assessment Modules Formatted as Moodle Quizzes**

Poster — *Robert E. Greeney, Holyoke Community College, 76 McClellan St., Amherst, MA 01002; rgreeney@hcc.edu*

I have developed a wide variety of physics learning and assessment exercises to be shared, used, and enhanced over time through peer collaboration among physics instructors. These exercises are authored in the format of Moodle Quizzes. The exercises are easily shared with anyone who has access to Moodle Learning Management System (LMS). Motivation for this initiative includes: a) Enhanced learning of physics, b) Convenient and effective assessment vehicles that promote learning, c) Easily shared and used OER learning and assessment exercises, d) Promote creative and productive collaboration among physics instructors, e) Quality cost saving options for faculty and students, and f) Contribute to the growth and improvement of OER in physics.

**PST2B12: 10:15-11:00 a.m. Role of Characteristics of Bodies in Newton's Third Law of Motion**

Poster — *Ajay Kumar Sharma, Fundamental PHYSICS Society, His Mercy Enclave Post Box 107 GPO Shimla 171001 HP INDIA shimla, HP 171001 India ajay.plus@gmail.com*

The third law establishes universal equality between action and reaction. The law is practically expressed in terms of forces. In third application of third law at page 20 of the Principia, Newton stated "If a body impinges upon another and by its force change the motion of the other, that body also will undergo an equal change, in its own motion, towards the contrary part. Mathematically forward velocity of target,  $V_{\text{forward}} = (U_{\text{forward}} - U_{\text{backward}}) m/M$  If target is heavier and remains at rest e.g. a ball impinges a heavy body then  $V_{\text{forward}} = 0$ ,  $U_{\text{forward}} = U_{\text{backward}}$  or projectile must rebound with initial velocity. In this case characteristics, nature, compositions of bodies (steel, rubber, spring, chewing gum) are practically and experimentally significant. These can be taken in account if law is generalised i.e. reaction is proportional to action through coefficient of proportionality.

## Physics Education Research II

### PST2C01: 9:30-10:15 a.m. Building on Institutional Efforts: Results from the TRESTLE Project\*

Poster – Stephanie Chasteen, University of Colorado Boulder, 247 Regal St., Louisville, CO 80027; stephanie.chasteen@colorado.edu

The University of Colorado Boulder has benefited from decades of programs aimed at STEM education improvements, including the Science Education Initiative (SEI; 2005-2014), initiated by Carl Wieman. The SEI provided funding and training for postdoctoral fellows to partner with faculty in STEM departments on course transformation. In 2015, seven institutions joined forces to apply the SEI model across a variety of institutional contexts, creating the Transforming Education, Stimulating Teaching and Learning Excellence (TRESTLE; <http://trestlenetwork.org>) network. At CU Boulder, the TRESTLE project has provided a mechanism for faculty involved in the former SEI to continue to engage in educational transformation, and to involve faculty newer to this work, through course transformation awards and faculty learning communities. In this poster I will share the approach used at CU Boulder, initial outcomes of the project, and implications for supporting sustained faculty engagement in educational improvements.

\*This material is based upon work supported by the National Science Foundation under Grant No. 1525331.

### PST2C02: 10:15-11:00 a.m. Comparative Experiments: Investigating Student Reasoning with Pictorial and Graphical Data

Poster – Jacob Cermak, Illinois State University, 169 E Prairie Ave., Lombard, IL 60148; jcermak97@gmail.com

Rebecca J. Rosenblatt, Raymond Zich, Amber Sammons, Illinois State University

In this study, we performed several comparative experiments exploring changes to students' response patterns and reasoning due to task variations. Students worked on tasks reasoning with sets of graphed and pictured data. We explored the effects of graph style (scatter vs. bar), graph data (numerical vs. percentage), question wording (presence vs. absence of a "none-of-the-above" answer), data change (countable vs. non-numerical variation), and time spent (required wait time vs. no wait time). These comparative studies showed several aspects of student reasoning with data. While most students will create a numerical bar graph when asked to make a graph, there is no disparity in students' skills interpreting other graphs. The absence of a "none-of-the-above" answer causes lower consistency of responses. Student correctness and reasoning improves when students are required to spend longer with a set of data. Lastly, some students struggle reasoning with pictured data that does not numerically change.

### PST2C03: 9:30-10:15 a.m. Comparatives about Beginnings of the Teaching of Physics in Latin America

Poster – Jhonny Alexis Medina Paredes, Universidad Austral de Chile, Instituto Politécnico Nacional, Legaria 694, Col. Irrigación, México, México 11500 México; jhonnymedina@uach.cl

Mario Humberto Ramírez Díaz, Instituto Politécnico Nacional

In the Latin American region from colonial times with ecclesiastical institutions, especially the teaching of science in general and physics in particular has had great importance in the training of scientists and engineers. However, each country since its independence has given a particular importance to some physics themes in function of their national characteristics, an example is the minery in Colombia or wood in Chile. In this work we show a comparative between some Latin American countries (Argentina, Colombia, Chile and México) and their first efforts to introduce the physics in schools and develop a scientific culture around this discipline until the formation to the first physics schools in the region.

### PST2C04: 10:15-11:00 a.m. Comparing Methods for Addressing Missing Data for Concept Inventories

Poster – Jayson M. Nissen, California State University - Chico, 101 Holt Hall, Chico, CA 95929; jnissen1@csuchico.edu

Robin Donatello, Ben Van Dusen, California State University - Chico

The most common method for addressing missing data in the PER literature is complete case analysis, where researchers only analyze matched samples. However, many statisticians recommend researchers use multiple-imputation (MI) to address missing data. We used simulated datasets to compare estimates of student learning using complete case analysis and MI. We based the simulated datasets on grades and concept inventories from 1,310 students in three physics courses and grade distributions from 192 STEM courses. We created missing data in the simulated datasets based on participation models from Jariwala et al. (PERC, 2017). Results showed that complete-case analysis tended to overestimate scores with a larger effect on the posttest but that MI only slightly overestimated scores. To improve the accuracy, precision, and utility of pre-/post-CI measurements, we recommend that researchers use MI and that researchers report descriptive statistics for both the participants and non-participants in their studies.

### PST2C05: 9:30-10:15 a.m. Comparing Student Performance Across Closed-Response and Open-Response Assessments

Poster – Cole J. Walsh, Cornell University, 118 Prospect St. Apt. 3B, Ithaca, NY 14850-5645; cjw295@cornell.edu

Katherine N. Quinn, N.G. Holmes, Cornell University

Closed-response diagnostic assessments are often developed from open-response versions, where students' responses are used to generate the closed-response options. Similarities in student performance between the two versions are typically used as a measure of validity. The Physics Lab Inventory of Critical thinking (PLIC) was developed in the same way, using a "select multiple responses" closed-response assessment. This format reflects the fact that students and experts expressed multiple possible correct answers to many of the questions. A previous study on the Colorado Upper-division Electrostatics Diagnostic (CUE) reported no significant differences in student performance and completion time between an open-response version and a "select multiple responses" version of their assessment. However, in our analysis of the PLIC, we have found noticeable differences between the two versions. We'll discuss possible explanations for these differences in terms of the validity of the assessment and student thinking, as well as implications for efficient evaluation of students' critical thinking.

### PST2C06: 10:15-11:00 a.m. Conceptual Difficulties Faced by College Students in Understanding Hydrodynamics

Poster – Arturo C. Marti, UdelaR, Montevideo, Uruguay, Igua 4225, Montevideo, 11400 Uruguay marti@fisica.edu.uy

Alvaro Suarez, CES-ANEP, Uruguay

Sandra Kahan, UdelaR, Montevideo, Uruguay

Genaro Zavala, Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, Monterrey 64849, Mexico Facultad de Ingeniería, Universidad Andres Bello, Santiago 7500971, Chile

The physics of ideal fluids is studied at the introductory level in first-year university courses. An in-depth understanding of this topic requires, in addition to a knowl-

edge of the basics of classical mechanics (statics, kinematics and dynamics), knowledge of the specific concepts to fluids such as current lines, pressure, propulsion, and conservation of different physical quantities. Physics education research shows that the conceptual difficulties to understand the phenomena associated with fluids have received relatively uneven attention. Here we describe a study on the conceptual difficulties faced by college students in understanding hydrodynamics of ideal fluids. This study was based on responses obtained in hundreds of written exams complemented with several oral interviews, which were held with first-year Engineering and Science university students. Their responses allowed us to identify a series of misconceptions. The most critical difficulties arise from the students' inability to establish a link between the kinematics and dynamics of moving fluids, and from a lack of understanding regarding how different regions of a system interact.

**PST2C07: 9:30-10:15 a.m. Connecting Three Pivotal Concepts in K-12 Science State Standards and Maps of Conceptual Growth to Research in Physics Education\***

Poster – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; [clsingh@pitt.edu](mailto:clsingh@pitt.edu)

Christian Schunn, University of Pittsburgh

We describe three conceptual areas in physics that are particularly important targets for educational interventions in K-12 science. These conceptual areas are force and motion, conservation of energy, and waves which were prominent in the US national and four US state standards that we examined. The four U.S. state standards that were analyzed to explore the extent to which the K-12 science standards differ in different states were selected to include states in different geographic regions and of different sizes. The three conceptual areas that were common to all the four state standards are conceptual building blocks for other science concepts covered in the K-12 curriculum. Since these three areas have been found to be ripe with deep student conceptual difficulties that are resilient to conventional physics instruction, the nature of difficulties in these areas is described, along with pointers towards approaches that have met with some success in each conceptual area.

\*We thank the National Science Foundation for support.

**PST2C08: 10:15-11:00 a.m. Course Reform vs. Lab Reform: Impact on Student Development**

Poster – Marina Malysheva, Rutgers University, 10 Seminary Pl., New Brunswick, NJ 08901; [malyshev@rutgers.edu](mailto:malyshev@rutgers.edu)

Joshua Rutberg, Eugenia Etkina, Rutgers University

Traditional physics labs have been shown to have little effect on student learning when it comes to both knowledge of physics and scientific abilities. Reformed labs, such as ISLE-based lab, have been shown to significantly improve student scientific abilities when used in conjunction with trained TAs and a course emphasizing the ISLE framework in all its components. We reformed a lab course for second-year engineering students to implement ISLE labs without reforming lectures and recitations. The TAs in the course were undergraduates who were trained in ISLE during one three-hour meeting. We examined lab work done by students, observations of students working in a lab and their performance on course exams to determine whether using ISLE only in the labs with minimally trained TAs allows us to replicate the results from previous studies.

**PST2C09: 9:30-10:00 a.m. Culture and Ideology in How LAs “See” (In)equity in Student Groups\***

Poster – Hannah C. Sabo, The University of Maryland, 3942 Campus Dr., College Park, MD 20742; [hsabo13@gmail.com](mailto:hsabo13@gmail.com)

Chandra Turpenbe, Ayush Gupta, Jennifer Radoff, Andrew Elby, University of Maryland, College Park

Learning Assistant (LA) programs have emerged within PER as an effective model for curricular and cultural transformation in undergraduate learning environments. At UMD, adapting from the CU-Boulder model, we started an LA program with two novel and interlinked foci: (1) LAs all mentor teams of engineering students in a team-based first-year engineering design course, and (2) we scaffold the LAs in fostering equitable team dynamics and collaboration. In this poster, we analyze LAs' interpretations of teamwork troubles and instructional responses. We show that LAs' actions and responses more frequently embodied ideological assumptions foregrounding individual merit and responsibility, treating individuals as autonomous agents divorced from their settings, and significantly backgrounding relational dynamics and systems-based analysis of teamwork troubles. These assumptions reflect aspects of broader STEM culture. These observations help us identify gaps in the design of the pedagogy seminar that we hope to address in future iterations.

\*Work supported by NSF#1733649

**PST2C10: 10:15-11:00 a.m. Demonstration Recognition Among 1st-6th Grade Students: A Program Effectiveness Study**

Poster – Patrick R. Morgan, Michigan State University, 755 Science Rd., East Lansing, MI 48824; [morgan@pa.msu.edu](mailto:morgan@pa.msu.edu)

Since 2011, the Science Theatre program at Michigan State University (MSU) has been visiting schools in the Upper Peninsula during the MSU Spring Break. These schools are only visited once a year, and otherwise have little or none science outreach exposure. In March of 2018, an adapted Draw-A-Scientist-Test (DAST) was conducted among several elementary schools. This test was looking for any evidence of demonstration recognition among grade school students, who have been seeing this program once each year since 2013. The results of this survey will be presented and discussed, as well as any notable trends or patterns.

**PST2C11: 9:30-10:15 a.m. Demonstration Recognition Among 9th-12th Grade Students: A Program Effectiveness Study**

Poster – Patrick R. Morgan, Michigan State University, 755 Science Rd., East Lansing, MI 48824; [morgan@pa.msu.edu](mailto:morgan@pa.msu.edu)

Since 2011, the Science Theatre program at Michigan State University (MSU) has been visiting schools in the Upper Peninsula during the MSU Spring Break. These schools are only visited once a year, and otherwise have little or none science outreach exposure. In 2017, a survey was conducted among 157 high school students at St. Ignace Senior High School to look for any form of demonstration recognition. The goal was to find evidence that these students, who have seen the program once each year, would be able to recognize and identify some of the demonstrations. What we found was a much greater level of recognition than anticipated, along with a recognition of terminology and topics discussed, suggesting that there is a form of learning. These results, as well as the 2018 follow-up survey, will be presented and discussed.

**PST2C12: 10:15-11:00 a.m. Denoting Leadership Actions/Traits in Group Work**

Poster – Kristina Griswold, Florida International University, Michigan State University, 129 Highland Ave., East Lansing, MI 48823; [kgriswold28@gmail.com](mailto:kgriswold28@gmail.com)

Daryl McPadden, Marcos Caballero, Paul Irving, Michigan State University

P<sup>3</sup> is an introductory mechanics based physics class at MSU that replaces lectures with a PBL learning environment. To promote the development of group based practices, students all receive group and individual feedback at the end of each week. The groups are comprised of four students, one of which often takes on the role of being the group's "leader". Developing leadership-based skills is a specific learning goal of the P<sup>3</sup> learning environment and the goal of this research is to examine what actions/traits students in P<sup>3</sup> demonstrate while working in their group. The initial phase of this study examines multiple pieces of literature to identify possible

characteristics and behaviors that may present themselves in potential leaders. In this poster, we present the initial phase of our code book and a preliminary example of how it can be used to denote leader(s) and followers in our case study.

**PST2C13: 9:30-10:15 a.m. Designing a Dashboard to Evaluate Student Engagement with PhET Simulations**

Poster – Diana Berenice López-Tavares, Polytechnic National Institute, Calzada Legaria 694, Mexico City, MEX 11500 dianab\_lopez@hotmail.com

Sam Reid, Katherine Perkins, University of Colorado Boulder

Carlos Aguirre-Velez, Polytechnic National Institute

Do you assign PhET simulations for homework? Do you wonder how your students are engaging with the simulations outside of class? In this poster, we present prototypes of a new dashboard design that aims to provide teachers with useful information about the level of student engagement that their activities generate with PhET Interactive Simulations. We utilize PhET-iO simulations, which are enhanced with the ability to capture and record students' mouse activity as they interact with the simulation. The dashboard uses several approaches to visualize the students' mouse activity data, showing individual student interaction patterns with the simulation as well as the aggregated information of an entire group. We invite you to review and feedback on these dashboard designs with your ideas for improvements.

**PST2C14: 10:15-11:00 a.m. Developing and Evaluating a Tutorial on the Double-Slit Experiment**

Poster – Ryan T. Sayer, Bemidji State University, 1500 Birchmont Dr. NE, Bemidji, MN 56601-2699; rsayer@bemidjistate.edu

Alexandru Maries, University of Cincinnati

Chandrulekha Singh, University of Pittsburgh

Learning quantum mechanics is challenging, even for upper-level undergraduate and graduate students. Interactive tutorials that build on students' prior knowledge can be useful tools to enhance student learning. We have been investigating student difficulties with the quantum mechanics pertaining to the double-slit experiment in various situations. Here we discuss the development and evaluation of a Quantum Interactive Learning Tutorial (QuILT) which makes use of an interactive simulation to improve student understanding. We summarize common difficulties and discuss the extent to which the QuILT is effective in addressing them in two types of physics courses. We thank the National Science Foundation for their support.

**PST2C15: 9:30-10:15 a.m. Developing and Validating a Conceptual Survey to Assess Introductory Students' Understanding of Thermodynamics\***

Poster – Chandrulekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Ben Brown, University of Pittsburgh

We discuss the development and validation of a conceptual multiple-choice survey called the Survey of Thermodynamic Processes and First and Second Laws (STPFaSL) suitable for introductory physics courses. The survey was developed taking into account common student difficulties with these concepts and the incorrect answers to the multiple-choice questions were designed based on the common student difficulties. After the development and validation of the survey, the final version was administered at six different institutions and the performances of the same type of students, e.g., calculus-based introductory students, from different institutions are similar. In particular, the survey was administered to introductory physics students in various traditionally taught calculus-based and algebra-based classes in paper-pencil format before and after traditional lecture-based instruction in relevant concepts. We also administered the survey to upper-level undergraduates majoring in physics and PhD students for bench marking and content validity and compared their performance with those of introductory students for whom the survey is intended. We find that although the survey focuses on thermodynamics concepts covered in introductory courses, it is challenging even for advanced students. Findings will be presented.

\*We thank the National Science Foundation for support.

**PST2C17: 9:30-10:15 a.m. Do I Belong Here?: Understanding Participation and non-Participation in a Contentious "Board" Meetings**

Poster – Jared L. Durden, Ozarks Technical Community College, 1001 E Chestnut Expy., Springfield, MO 65802; durdenj@otc.edu

Brant Hinrichs, Drury University

In University Modeling Instruction, students work in small groups on a problem and then hold a large-group discussion to develop whole-class consensus. While such interactive-engagement can help students learn, evidence suggests not all students share the same experience or feel equally included. We have developed a preliminary coding scheme based on Wegner's framework from "Communities of Practice", which identifies student modes of belonging through participation and non-participation. In this poster, we code and analyze reflective student writing assignments on a particularly contentious mid-semester large group discussion and individual end of the semester interviews with each student about the course structure itself. Using this lens, we identify students' varying perceptions of the large group discussion and how it influenced their participation. By developing a descriptive model of student engagement, we seek to develop a predictive model to inform professional development for instructors who teach in student centered classrooms.

**PST2C19: 9:30-10:15 a.m. TA Performance at Identifying Student Difficulties in Electricity and Magnetism**

Poster – Nafis I. Karim, University of Pittsburgh, 3941 O'Hara St, Allen Hall, Pittsburgh, PA 15260; nik49@pitt.edu

Alexandru Maries, University of Cincinnati

Chandrulekha Singh, University of Pittsburgh

We discuss research involving teaching assistants' knowledge of introductory students' alternate conceptions in electricity and magnetism as revealed by the Conceptual Survey of Electricity and Magnetism (CSEM). For each item on the CSEM, the TAs were asked to (1) identify the most common incorrect answer choice of introductory physics students and (2) predict the percentage of introductory students who would answer the question correctly in a post-test. We used CSEM post-test data from approximately 400 introductory physics students, as in the original CSEM article, to assess the extent to which the TAs were able to identify the alternate conceptions of introductory students related to electricity and magnetism. We find that the TAs struggled to think about the difficulty of the questions from introductory students' perspective and they often underestimated the difficulty of the questions. We thank the National Science Foundation for support.

**PST2C20: 10:15-11:00 a.m. Do Students Buy-in to Studio Physics Classes?: Survey Analysis**

Poster – Matthew Wilcox, University of Central Florida, 4111 Libra Dr., Orlando, FL 32816; mwilcox1@knights.ucf.edu

Jacquelyn J. Chini, University of Central Florida

In studio physics classes, instructors may use reformed instructional strategies that students might not expect when they register for the class. As a result, instructors might experience student resistance to these strategies, and that resistance may discourage their continued use of the research-proven strategies. We hypothesize that instructors could reduce student resistance through discussions with students about expectations for the class format and why students should agree with the format. We are investigating how well students agree with the studio format, how their agreement affects their performance in class, and what instructors do to gain student agreement. Two surveys were created that measure student agreement and instructor methods to achieve student agreement. We report on the results of these surveys, finding that student agreement varies greatly within a class but is fairly consistent across physics classes. Additionally, we find that instructors tend to use student-centered methods to discuss student-centered activities.

**PST2C21: 9:30-10:15 a.m. Who Should Study Harder, and When?**

Poster – Zhongzhou Chen, University of Central Florida, Physics Department, 4111 Libra Drive, Orlando, FL 32828; Zhongzhou.Chen@ucf.edu

Geoffrey Garrido, Andrea Tama, Michael Mikulec, University of Central Florida

Kyle Whitcomb, University of Pittsburgh

When is it a good idea to ask students to “spend more time studying”? Correlating learning behavior and effort with students’ learning outcome at scale has always been a challenging question. Mastery-based online instructional design significantly improves our ability to answer this question by integrating formative assessment into the learning process. By analyzing data collected from multiple online learning modules using the UCF Obojobo platform, we’re able to suggest the optimum amount of time that students should spend on studying each module, as well as identify those students who are probably spending an insufficient amount of time studying. In addition, it also identifies students who spend too much time and is likely struggling with the content. The results of this research could in the future lead to an automated system that provides students with personalized learning guidance.

**PST2C22: 10:15-11:00 a.m. Research Exploring Relevance with a Systems View of Students’ Lives**

Poster – Abhilash Nair, Michigan State University, 1310 BPS, 567 Wilson Rd., East Lansing, MI 48823; nairabhi@msu.edu

Vashiti Sawtelle, Michigan State University

Physics reasoning and content knowledge are positioned as being relevant to students earning a degree in STEM. Meanwhile, research has documented that students often leave the classroom stating that physics is less connected to the world than when they started the course. Students’ negative responses are often interpreted as students not perceiving the relevance of physics to different facets of their lives: the real world, their everyday life, their personal interests, or their future careers. We present work furthering our understanding of the relevance of physics by taking a systems view to characterize connections and relationships between physics and students’ lives. Utilizing case studies of students in an introductory physics for the life-sciences course we present an expanded view on relevance. We discuss how this systems view develops a richer account of the ways in which students may find physics relevant.

**PST2C23: 9:30-10:15 a.m. Embodying the Abstract or Abstracting from the Body**

Poster – Elias Euler, Uppsala University, Ångströmlaboratoriet, Lägerhyddsvägen 1 Uppsala, 75120 elias.euler@physics.uu.se

Elmer Rådahl, Bor Gregorcic, Uppsala University

Some discussions of kinesthetic learning activities include a distinction between (1) activities that involve students’ bodies as symbolic representations and (2) activities that incorporate students’ bodies as sensors for experiencing things such as forces and torques. In this poster, we go beyond this binary distinction to propose a theoretical interpretation of how the body can be included in physics learning. We then use our interpretation in discussing an example from a learning activity where a pair of students spontaneously recruited an embodied metaphor as part of their reasoning about binary stars.

**PST2C24: 10:15-11:00 a.m. Engaging Students in Developing and Using Models through Assessments**

Poster – Katherine C. Ventura, Kansas State University, 625 Northfield Road Manhattan, KS 66502; katventura@ksu.edu

James T. Laverty, Kansas State University

Recent national reports have elevated learning how to do physics to the same level of importance as learning the concepts of physics. By making these “scientific practices” more prominent in assessments, we hope to see a shift in students’ focus toward the process of solving physics problems. Assessing scientific practices is important to determining if we, as educators, are facilitating students’ abilities to engage in the process of science. We are investigating how assessments can be designed to engage students in the practice of Developing and Using Models. Using a think-aloud protocol we interviewed students while working on these assessments and analyze the interviews using Grounded Theory. We are looking at two questions: do students engage with the practice and do students get the problem correct? Observing students’ engagement informs us how to develop assessments to engage students and how well we can assess practices.

**PST2C25: 9:30-10:15 a.m. Enhancing the Resolution of Learning Assessment through Online Modularized Instructional Design**

Poster – Kyle M. Whitcomb, \* University of Pittsburgh, 3289 Dawson St, Apt 5, Pittsburgh, PA 15213-4549; kmw136@pitt.edu

Zhongzhou Chen, University of Central Florida

Chandralekha Singh, University of Pittsburgh

Online learning technology can greatly extend the boundaries of traditional assessment by providing new types of tasks and collecting a richer variety of data. We present a case of assessment design using a sequence of three online learning modules, presenting students with a transfer task, a worked example and a second transfer task in sequence. This new design enables us to measure students’ immediate knowledge gain and near transfer ability, as well as “preparation of future learning” effects, after studying an online problem solving tutorial. In addition to learning outcomes, data from the assessment also sheds light on students’ motivations, learning habits and learning strategies, which provides instructors with a more holistic picture of each individual student.

\*Sponsored by Zhongzhou Chen

**PST2C26: 10:15-11:00 a.m. Evidence for Effective Group Work in Studio Physics**

Poster – Trever Bench, Texas A&M University-Commerce, Department of Physics and Astronomy, Commerce, TX 75429; Tbench@leomail.tamuc.edu

Robynne Lock, Melanie Schroers, N. Gentry, Texas A&M University- Commerce

Group work in environments such as studio physics, or SCALE-UP, has been promoted as a method of improving students' conceptual understanding and problem-solving skills. However, strategies for creating effective groups and teaching students to work together effectively in university physics classes have not been sufficiently tested. In order to study these strategies, we must first determine what constitutes an effective group and what constitutes an ineffective group. We recorded video of groups in the introductory calculus-based physics sequence at Texas A&M University-Commerce over the course of several semesters. Groups were recorded completing tutorials, problem-solving activities, and labs. In each class section, the instructor suggested a "good" group and a "bad" group to be recorded. Video data has been coded using epistemological framing, and social network analysis has been conducted. We present evidence for what constitutes effective group work.

**PST2C27: 9:30-10:15 a.m. Examination of Epistemic Agency Due to Implementing Culturally Relevant Practices**

Poster – Clauseell Mathis, Florida State University, 1130 High Meadow Dr., Tallahassee, FL 32306-9936; cm15j@my.fsu.edu

Mark Akubo, Sherry Southerland, Florida State University

This qualitative case study examines how implementing culturally relevant practices in the classroom activates students' epistemic agency. A revised physics curriculum is developed in order to use students' cultural resources as a pedagogical tool. Teachers enacted classroom lessons where content was problematized to address social inequities in the classroom. A developed instrument - the classroom observation protocol for epistemic agency (COPEA) will be used to document and examine instances of students' epistemic agency. We analyze video data in pursuit of exploring how the implementation of culturally relevant practices may relate to the quality of epistemic agency exercised by students. It is important to search for insights into instructional strategies that draw upon students' cultural resources, foregrounding shared-authority and supporting their taking of responsibility for the construction of knowledge in the classroom community. This may reveal insights into long term affordances and constraints for diversity in physics.

**PST2C28: 10:15-11:00 a.m. Examining Student Tendencies to Explore Alternate Possibilities\***

Poster – J. Caleb Speirs, University of Maine, 19 Getchell St., Brewer, ME 04412; caleb.speirs@gmail.com

MacKenzie R. Stetzer, University of Maine

Beth A. Lindsey, Penn State Greater Allegheny

As part of a multi-year, multi-institutional effort, we have been investigating and assessing the development of student reasoning skills in introductory calculus-based physics courses. Research in cognitive science suggests that there may be a link between student ability to consider alternative possibilities and student performance on physics problems — particularly problems in which salient distracting features appear to prevent students from accessing relevant knowledge. We have piloted new tasks designed to measure student ability to consider multiple possibilities when answering a physics problem. These tasks measure the relative accessibility of a mental model (or possibility) as well as student ability to recognize whether or not this model is consistent with given problem constraints. An overview of these tasks will be provided and preliminary results will be discussed.

\* This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DRL-0962805.

**PST2C29: 9:30-10:15 a.m. Exploring Students' Understanding of the Motion of Rigid Body\***

Poster – Min-Fan Hsieh, National Changhua University of Education, 6F., No.25, Sec. 3, Hankou Rd., Taichung, Taiwan 404 Taiwan minfan.hsieh@gmail.com

Shih-Yin Lin, National Changhua University of Education

One topic typically discussed in an introductory mechanics course is the motion of rigid body. However, our anecdotal experiences suggest that many students do not have a good understanding of the motion of rigid body, especially when rotation is involved. For example, few students know that any pair of particles on a rigid body doesn't have relative velocity toward or away from each other. In addition, students may not realize the constraints of choosing a reference point for torque and moment of inertia in the rotational equations of motion. In this study, a set of problems about the motion of rigid body and relevant rotational equations of motion is developed and administered to a group of students who have taken introductory mechanics course. Findings from the study will be presented.

\*Supported by the Ministry of Science and Technology, Taiwan under grant No. MOST 106-2511-S-018-003-MY2.

**PST2C30: 10:15-11:00 a.m. Exploring Trends in Context Dependence on the QMCA**

Poster – Adam T. Quaal, California State University, Fullerton, McCarthy Hall, Fullerton, CA 92831; adam.quaal@gmail.com

Gina Passante, California State University, Fullerton

Steven J. Pollock, University of Colorado, Boulder

Homeyra R. Sadaghiani, California State Polytechnic University, Pomona

The Quantum Mechanics Concept Assessment (QMCA) was developed to gauge the effectiveness of different curricular approaches to upper-division quantum mechanics (Sadaghiani & Pollock, 2015). Due in part to the increased popularity of a spins-first instructional approach to teaching quantum mechanics, we modified several QMCA questions to a spins context. For example, a question about time evolution for a particle in an infinite square well was modified to a question about time evolution for a spin-1/2 particle in a magnetic field. In this work, we compare student responses to analogous questions in the spins and wave functions contexts. Data is taken from several administrations of the QMCA in spins-first classes at three institutions. These results will help inform an updated version of the QMCA.

**PST2C31: 9:30-10:15 a.m. Gateways ND: Investigating Professional Development at North Dakota State University\***

Poster – Alistair G. McInerney, North Dakota State University, 1340 Administration Ave., Fargo, ND 58102; Alistair@McInerney.org

Mila Kryjevskaja, Jared Ladbury, Paul Kelter, North Dakota State University

A North Dakota State University professional development program is designed to facilitate and improve the use of active learning pedagogies at the college level. Over the course of two years participants attend four 2-day workshops and regular Faculty Learning Communities. While evaluation of the program is being approached from many angles, the research presented here discusses our use of the Theory of Planned Behavior (TPB) and the Retrospective-Pretests. We will talk about the link between participants' beliefs and intentions as well as their actions in the classroom (as measured by COPUS). We will show that our use of the retrospective-pretests allows us to detect changes in the impact of the program on its participants that traditional pre-tests would fail to capture.

\*This material is based upon work supported by the National Science Foundation under Grant No. DUE-1525056.



**PST2C32: 10:15-11:00 a.m. Graduate Teaching Assistants' Perceptions of a Context-Rich Introductory Physics Problem**

Poster – Melanie L. Good, 2017 Noble St., Sharpsburg, PA 15215; melanie.l.good@gmail.com

Emily Marshman, Chandralekha Singh, University of Pittsburgh

Edit Yerushalmi, Weizmann Institute of Science

Posing the same physics problem scenario in different ways can emphasize learning goals for students, such as developing expert-like problem-solving approaches. In this investigation, we examined graduate teaching assistants' (TAs') views about a context-rich introductory physics problem within a semester-long TA professional development course. The TAs were asked to list the pros and cons of a context-rich problem, rank the problem in terms of its instructional benefit and the level of challenge it might produce for their students, and describe when and how often they would use it in their own classes if they had complete control of teaching the class. We find that TAs did not find the context-rich problem to be instructionally beneficial and were unlikely to use it in their own courses. Many TAs expressed their concerns as being due to the problem seeming to be unclear or excessively challenging and time-consuming for their students. These findings suggest that there is a discrepancy between the TAs' perception of a context-rich problem and the benefits of problems posed in this manner according to the physics education research literature.

**PST2C33: 9:30-10:15 a.m. How to Train Ethical Behavior in Research: Fixing Confirmation Bias**

Poster – Martin M. Stein, Cornell University, 914 East State St., Ithaca, NY 14850; ms3452@cornell.edu

N G. Holmes, Emily M. Smith, Cornell University

In Intro Physics Labs we have seen students engaging in questionable research practices that seem to arise from a confirmation bias. In our labs, students are free to change the experimental setup and are not graded on the correctness of their results. Analyzing video and audio recordings, as well as lab books, we observed some students skillfully manipulating the experimental setup, and data that contradicted a presented model, to yield the expected result. While some students did not record these practices in their write-ups, we were surprised by other students accurately documenting questionable research behavior. A subsequent discussion revealed the inadequacy of the model. Towards the end of the semester, some students provided unsolicited reflections on their biases, indicating that they remember and value such an experience in their scientific education. We hope this experience serves them as a preparation for learning about the responsible and ethical conduct of research.

**PST2C34: 10:15-11:00 a.m. I Just Did What? An Evaluation of Student Self-Assessment**

Poster – Danielle Bugge, Rutgers University, 8 Perrine Path, West Windsor, NJ 08550; danielle.bugge@rutgers.edu

Eugenia Etkina, Rutgers University

Within high school classrooms, first-year physics students engage in investigations that focus on the development of scientific abilities. Students in ISLE classrooms are provided with scientific ability rubrics as tools to assist with their experimental design procedures and written laboratory reports. These rubrics contain elements of the science practices that students should consider when planning, designing, carrying out, and analyzing their investigations. When writing up their findings, students self-assess themselves. They are expected to cite specific evidence within their report of where they meet criteria for performance for each of the abilities outlined on the rubric. Over the course of a school year, we tracked student progress with self-assessment on their written laboratory reports. We looked at whether or not their self-evaluations of and proficiency with varying abilities improved over the school year taking into account multiple exposures to the abilities, feedback, and the opportunity to revise their work.

**PST2C35: 9:30-10:15 a.m. Identifying and Scaling Up What Helps Women of Color Thrive**

Poster – Rose Young, 45541 Knoockeyon Lane, Great Mills, MD 20634-2486; Rnyoung@smcm.edu

Elizabeth Mulvey,

Vanessa Webb,

Apriel Hodari,

Angela Johnson,

Researchers from Eureka Scientific, Inc. and St. Mary's College of Maryland are conducting in-depth, mixed-method investigations of out-performing STEM departments in the United States and England in which women of color are thriving. The project identifies shared approaches across these departments; developing a body of tested, practical elements of success that STEM departments can adopt; and a set of measures that will let the departments monitor the success of their transformation process. The project will advance research-based knowledge to promote systemic change in STEM education and will provide a clearer understanding about factors that promote success for young women of color in a variety of institutional contexts. The project will culminate in a meeting with participants from 11 institutions who will examine the applicability of the findings at their home institutions including: doctoral universities, master's universities, baccalaureate colleges, open enrollment, public and private institutions. This poster will examine the quantitative data analysis conducted during this research.

**PST2C36: 10:15-11:00 a.m. Impact of Teaching Methods on Heterogeneity**

Poster – Claudia Schaeffle, University of Applied Sciences of Rosenheim, Germany, Hochschulstr. 1, Rosenheim, Bavaria 83024 Germany; claudia.schaeffle@fh-rosenheim.de

Elmar Junker, Silke Stanzel, University of Applied Sciences of Rosenheim

We report experiences from a five-year implementation project during which teaching formats fostering active learning methods have been introduced at the University of Applied Sciences Rosenheim, Germany for engineering students in the first year in physics. We investigate the increasing heterogeneity in the previous knowledge as well as the learning gain in different courses by force concept inventory (FCI), exams and evaluation of students' feedback. Our results show, that: 1. The previous knowledge depends strongly on the type of school graduation. 2. The FCI-Pretest-results are nearly the same for students today and 15 years ago. 3. The learning gains with active learning methods (Just-in-Time-Teaching, Peer Instruction and Tutorials after McDermott et al.) are significantly higher than with traditional lecture. 4. Students appreciate active learning methods and spend more time on the subject. 5. Even with active learning methods the heterogeneity cannot be resolved after one year of study.

**PST2C37: 9:30-10:15 a.m. Improving Student Understanding of Coulomb's Law and Gauss's Law\***

Poster – Chandralekha, Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Jing Li, University of Pittsburgh

We discuss an investigation of the difficulties that students in a university introductory physics course have with Coulomb's law and Gauss' law and how that research was used as a guide in the development, validation, and evaluation of tutorials on these topics to help students learn these concepts. The tutorial uses a guided inquiry-based approach to learning and involved an iterative process of development and evaluation. The final version of the tutorial was administered in several sections of a calculus-based introductory physics course after traditional instruction in relevant concepts. We discuss the performance of students in individual interviews and on the pre-test administered before the tutorial (but after traditional lecture-based instruction) and on the post-test administered after the tutorial in three sections of the introductory physics course. We also compare student performance in several sections of the course in which students worked on the tutorial with another section in which students only learned via traditional lecture-based instruction. We find that students who used the tutorial performed significantly better compared to those who learned the material only via traditional lecture-based instruction.

\*We thank the National Science Foundation for support.

### **PST2C38: 10:15-11:00 a.m. Instructional Dilemmas Around Energy Representations: Learning Potentials in Faculty Communities**

Poster – Chandra Anne Turpen, University of Maryland, College Park, 6701 Adelphi Rd., University Park, MD 20782; chandra.turpen@colorado.edu

Fred Goldberg, Adriana Corrales, San Diego State University

Edward Price, California State University, San Marcos

Melissa Dancy, University of Colorado, Boulder

There is significant momentum around building professional learning communities for educators. However, more research is needed to understand how the design and emergent norms of such communities enable or constrain learning. We analyze how university educators with varying degrees of experience teaching with the Next Generation Physical Science and Everyday Thinking (Next Gen PET) curriculum enact conversational routines in professional development contexts that enable opportunities to learn [1]. Through analysis of community members' instructional dilemmas working with energy representations, we illustrate how the shared disciplinary and curricular context allows for collective interpretation to occur [2,3]. We argue that these conversations deepen educators' understanding of student learning in ways that likely have longer-term consequences for their pedagogical content knowledge.

[1] Work supported by NSF#1626496 [2] Horn, Garner, Kane, & Brasel (2017). *J. Teach. Ed.*, 68(1). [3] Horn & Kane (2015). *J. Learn. Sci.*, 24(3).

### **PST2C39: 9:30-10:15 a.m. Instructor Approaches to Teaching Computational Physics Problems in Problem-based Courses**

Poster – Alanna Pawlak, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824; pawlak@msu.edu

Paul W. Irving, Marcos D. Caballero, Michigan State University

An increasing number of introductory physics courses are seeking to incorporate "authentic practices", and one way they are doing this is by including computational problems. Computational problems offer students an opportunity to engage with the programming practices and numerical problem solving methods used by physicists. Understanding how instructors approach teaching such problems is important for improving instruction and problem design. We conducted a phenomenographic study using semi-structured interviews with instructors in a problem-based introductory mechanics course that incorporates several computational problems. The instructors we interviewed were undergraduate learning assistants, individuals who were previously successful as students in the course. Their prior involvement as students, along with their relatively fewer experiences with programming and physics compared to the faculty instructors, give them a unique perspective on teaching in the course. We present here the results of our analysis, which describe the experiences of learning assistants teaching computational problems in this course.

### **PST2C40: 10:15-11:00 a.m. Inventory of Academic Stress in Students Studying Physics in Engineering**

Poster – Oscar Jardey Suarez, Fundación Universidad Autónoma de Colombia, Calle 12 B No 4- 31, Bogotá, AA 11001 Colombia oscar.jardey.suarez@gmail.com

Alejandro Hurtado Marquez, Oscar Antonio Pulido Cardozo, Fundación Universidad Autónoma de Colombia

The main purpose of this paper is to disclose the results obtained after adapting and validating the Academic Stress Inventory ASI (initially proposed by Hernández, Polo y Pozo in 1996) with students studying physics in engineering. Academic stress, understood as the cognitive and physiological responses to the activities that oppose learning proper to the physics course. The validation is obtained through the reliability index of Cronbach's alpha, the exploration of the data is made from the Principal Component Analysis PCA. The ASI was increased from 23 to 28 items, with an extension of the domain in the Likert scale response from 1 to 7, Cronbach's alpha for typed items is 0.858. The PCA the sample adequacy measure of Kaiser-Meyer-Olkin was 0.733. The PCA yields 7 categories (individual work, physiological response to the physics class, peer interaction, insufficient time for activities, teacher support, stress-generating participation, peer competition).

### **PST2C41: 9:30-10:15 a.m. Investigating Grading Beliefs and Practices of Graduate Student Teaching Assistants Using a Rubric**

Poster – Ryan T. Sayer, Bemidji State University, 1500 Birchmont Dr. NE, Bemidji, MN 56601-2699; rsayer@bemidjistate.edu

Emily Marshman, Chandralekha Singh, University of Pittsburgh

Charles Henderson, Western Michigan University

Edit Yerushamli, Weizmann Institute of Science

Physics graduate teaching assistants (TAs) are often responsible for grading. Findings of physics education research (PER) suggest that instructors should use grading practices that place the burden of proof for explicating the problem-solving process on students to help them develop problem-solving skills and learn physics. However, TAs may not have learned effective grading practices and may hesitate to take off points if the final answer is correct but the problem-solving process is not explicated. This case study investigated whether TAs apply a PER-inspired grading rubric similar to PER experts and TAs' stated pros and cons of using such a rubric. We also examined whether discussions within a TA professional development course about the benefits of using such a rubric helped TAs shift where they place the burden of proof. Analysis of TAs' written responses, class discussions, and individual interviews suggest that a one-semester intervention was insufficient to change where the TAs placed the burden of proof. We thank the National Science Foundation for their support.

### **PST2C42: 10:15-11:00 a.m. Investigating Physics Self-Belief in Secondary Students**

Poster – Cynthia Reynolds, The College of New Jersey, 2000 Pennington Rd., Ewing, NJ 08628; reynolc5@tcnj.edu

AJ Richards, The College of New Jersey

There exists a shortage of students who enter an undergraduate program of study or intend to pursue a career in physics. Even more critical in this shortage is the underrepresentation of women and minority groups. The reasons for this shortage are not yet known. We have chosen to investigate the impact of students' physics self-belief on their likelihood to pursue physics as a career. We designed and administered a survey instrument to secondary level physics and physical science students. The survey was designed to help educators understand how the levels of self-efficacy of middle and high school level students change as they progress through their

educational careers in the subject of physics. The survey also investigated if a student's level of self-efficacy is directly related to how a student views a potential career in physics. In this presentation we will detail the trends we found between students' physics self-belief, demographics, and likelihood to choose physics as a career.

**PST2C43: 9:30-10:15 a.m. Investigating Reasons for Why Self-Paced Interactive Electronic Learning Tutorials Express a Challenge for Engaging Students**

Poster – Edana M. Wilke, University of Cincinnati, 2600 Clifton Ave., Cincinnati, OH 45025; wilkea@mail.uc.edu

Alexandru Maries, University of Cincinnati

Zhongzhou Chen, University of Central Florida

While the use and availability of electronic self-paced learning tools has been growing in recent years, research suggests that many students do not engage with the learning tools as intended, resulting in less than desirable transfer of learning. A critical issue then remains how to design the implementation of electronic self-paced learning tools to encourage students to engage with them properly from them. We conducted an investigation in which students in an introductory physics course used self-paced, interactive, electronic learning tutorials as an extra aid in preparing for exams. The tutorials were designed around a challenging problem, similar to what students may encounter in an exam. The tutorial divided the problem into a series of subproblems which take the form of multiple-choice questions, with the goal of guiding students to use effective problem-solving strategies. We investigated a potential approach to motivate students to actively engage with the tutorials. Students were divided in two groups, one which was required to attempt the tutorial problem (by submitting an answer) before being allowed to move on to the guided subproblems (referred to as the RQ group). The other group, NRQ group, was given an option to skip the tutorial problem and move on to the guided subproblems. We found evidence students in the RQ group were slightly more likely to learn from the tutorial than the NRQ group, suggesting that requiring students to initially think about the problem may force them to be more active in the tutorial. We also discuss other possible interventions based on our study.

**PST2C44: 10:15-11:00 a.m. Investigating Student Perceptions of Learning Assistants**

Poster – Virginia M. Coghlan, Kansas State University, 66352 Hampton PL, Apt. 2, Fort Riley, KS 66442; vcoghlan@phys.ksu.edu

James T. Laverty, Kansas State University

The Physics Department at Kansas State University recently initiated a Learning Assistant (LA) program. Previously, the studios of the department's two-semester calculus-based physics course were run by a lead instructor (faculty member or advanced graduate student) assisted by a TA (upper level undergraduate or new graduate student). The department replaced the TA in some studios with two LAs. We are conducting interviews with students who completed a studio with a TA and a studio with LAs. We are investigating the similarities and differences in the students' view of TAs versus LAs. This research will help us understand student perceptions of the LAs they encounter and to observe the impacts of the near-peer relationships between students and LAs.

**PST2C45: 9:30-10:15 a.m. Investigating Student Resources in Integrated Computational Science Courses**

Poster – Odd Petter Sand, CCSE, Dept. of Physics, University of Oslo, P.O. Box 1048 Blindern, Oslo, Oslo N-0316 Norway oddps@astro.uio.no

Marcos D. Caballero, CCSE, Dept. of Physics, University of Oslo and Department of Physics and Astronomy, Michigan State University

Christine Lindström, CCSE, Dept. of Physics, University of Oslo

Using the resources framework, the PER community has gained valuable insights into the cognitive nature of how students learn physics, and these insights are in turn helping to transform physics education. Our goal is to similarly investigate student resources in a computational setting and develop an analytical framework for how students use computation in a scientific setting. Ideally, building computation into science courses not only teaches students to use valuable tools, but also assists in a deeper understanding of the science itself. We present here initial findings from interviews and observations of first-year biology students learning computation in a course where programming, mathematics and biology concepts are deeply integrated.

**PST2C46: 10:15-11:00 a.m. Investigating the Effects of Modified Equipotential Diagrams on Student Interpretation**

Poster – Rebecca J. Rosenblatt, 218 Willard Ave., Bloomington, IL 61701; rosenblatt.rebecca@gmail.com

Jacob Cermak, Amber Sammons, Raymond Zich, Illinois State University

In this study, the effect of a visual change to equipotential diagrams is investigated. Equipotential diagrams are often drawn with a uniform color and thickness to each equipotential line. The values of each equipotential are usually not given and students must infer the "size" of the equipotential from the density of the lines and/or the sign of the point charge(s). Here we present the results from modifying equipotential diagrams to use color variation and line thickness to indicate the sign and amount of the potential. These changes — which are consistent with theories of grounded/embody cognition — exploit students' innate ability to perceive color and line thickness variations to communicate the variation of the electric potential. Students were randomly assigned to the traditional or modified diagrams and asked to compare electric potentials for indicated points on given diagrams. Preliminary results indicate that these modified color diagrams are helpful for instruction.

**PST2C47: 9:30-10:15 a.m. Know-Why in Determining Cross Product Directions in Introductory Electromagnetism**

Poster – Liang Zeng, The University of Texas-Rio Grande Valley, 1201 W. University Drive, Edinburg, TX 78539; liang.zeng@utrgv.edu

Yi Zeng, Nanchang Institute of Technology, Nanchang, Jiangxi, P. R. China

Vectors and cross products play a fundamental role in determining the directions of vectors in electromagnetism in introductory algebra-based physics course. Research studies have shown that students have a great deal of difficulty with vector operations in general and particularly with physics problem-solving related to vector cross products. General physics textbooks normally present physical mnemonic techniques (various left-hand rules and right-hand rules) to teach students how to determine the directions of the unknown vectors involved in cross products. Because knowledge includes both the "know-how" and "know-why," this paper argues that we need to teach students not only how to use the hand rules, but also why we use these hand rules by conceptually introducing the directional relationship among vectors in cross products to improve knowledge transfer skills.

**PST2C48: 10:15-11:00 a.m. Laboratories' Assessment in Terms of Flow Theory**

Poster – Anna F. Karelina, Saint Mary's College of California, 1928 St Marys Rd., Moraga, CA 94575; anna.karelina@gmail.com

One of the difficulties in designing an inquiry-based lab course is finding a balance between the tasks' difficulty and students' skills. Also, the clarity of tasks should leave a room for students' creativity and exploration. In this study, we used the flow theory [1] as a framework to create a tool for finding this balance. We developed a Likert scale survey with 7 questions related to the conditions of flow and students' attitude towards the developed labs. We analyzed students' answers to this

survey to find connection between the conditions of flow [1] and students' attitude towards the labs. This survey can be used as a helpful tool for labs' assessment and improvement.

[1] Csikszentmihályi, Mihály (1990), *Flow: The Psychology of Optimal Experience*, New York: Harper and Row

**PST2C49: 9:30-10:15 a.m. Learning Assistants as Constructors of Feedback: How Are They Impacted?**

Poster – Paul C. Hamerski, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824; tallpaul@msu.edu

Paul W. Irving, Daryl McPadden, Michigan State University

Project and Practices in Physics (P-Cubed) is a flipped section of introductory, calculus-based physics, which is designed with a problem-based learning approach where students work in groups on complex physics problems. Learning Assistants (LAs) are critical to the course, where they each function as a primary instructor for four to eight students by asking questions and prompting discussion during class. LAs in P-Cubed also write individualized weekly feedback to each of their students, which is meant to offer suggestions to the student for how to improve their work in class and provide the student with a justification for their in-class grade. We conducted semi-structured interviews with LAs -- selected to portray a broad range of approaches to feedback -- to examine the ways that they construct feedback and how this impacts their own experiences as students taking classes. In this presentation, we compare the reflections and experiences of these LAs.

**PST2C50: 10:15-11:00 a.m. Let's Talk About Equity – Two-Year College Students and Physics Culture**

Poster – Abigail R. Daane, South Seattle College, 6000 16th Ave. SW, Seattle, WA 98106; abigail.daane@gmail.com

Elizabeth A. Schoene, South Seattle College

We taught a week-long equity unit in an introductory calculus-based physics course, focusing on the effects of race and culture on the physics community. The demographics of these two-year college courses look vastly different than those of the physics field; students of color outnumber white students. Given this reversal of representation, our aim was to increase awareness of the racial inequity that is present in the rest of the physics community and to facilitate the development of support systems to move forward in STEM careers. We collected and analyzed written student reflections from these classes to better understand the views students of color bring to the equity conversation. We identified themes in their ideas about equity in physics and we argue that their responses indicate a need for explicit discussions in physics classrooms and the greater community.

**PST2C51: 9:30-10:15 a.m. LGBT+ in STEM: The Transgender Experience**

Poster – Vanessa S. Webb, Northern Virginia Community College, 10099 Tummel Falls Dr., Bristow, VA 20136; vasowe13@gmail.com

It has been widely reported that youth are more accepting of LGBT+ identities, and an increasing number of colleges and universities allow students to use gender-neutral pronouns. Yet, research on how inclusive STEM educational cultures are of sexual identity and gender fluidity is meager. According to a survey by the Human Rights Campaign, 75 percent of LGBT+ youth report that most of their peers have no problem with their LGBT+ identity, yet 4 in 10 say the community in which they live is not accepting (HRC, 2012). STEM cultures are configured within this broader context, and little is known about the LGBT+ acceptance and inclusion within them. In this poster we present interview results on the lived experiences of transgender undergraduates in physics, mathematics, and computer science, asking whether institutions that are more inclusive by gender and race, compared to that of other institutions, are more inclusive for them.

**PST2C52: 10:15-11:00 a.m. Relationship Between Stereotype Threat and Standardized Test Performance in Physics\***

Poster – Alexandru Mariés, University of Cincinnati, 3405 Telford St., Cincinnati, OH 45220; mariesau@ucmail.uc.edu

Chandralekha Singh, University of Pittsburgh

Prior research has shown that interventions even as small as requiring a test-taker to indicate his/her gender can activate stereotype threat in situations in which there are stereotypes about performance of males and females. We have conducted an investigation in which we used various interventions described in the literature as promoting or inhibiting stereotype threat and investigated the extent to which the interventions result in changes in the test-takers' performance on a standardized conceptual physics assessment. We also identified whether students themselves endorse the predominant stereotype (that in physics males outperform females) and the extent to which these beliefs are correlated with their performance. For example, do female students who endorse the stereotype perform worse than those who do not endorse it? This along with other questions are explored in detail.

\* Work supported by the National Science Foundation

**PST2C53: 9:30-10:15 a.m. Participation and Performance on Paper-based vs. Computer-based Low-Stakes Assessments**

Poster – Manher Jariwala, Boston University 590 Commonwealth Ave., Department of Physics, Boston, MA 02215; manher@bu.edu

Jayson Nissen, Ben Van Dusen, California State University, Chico

Eleanor W. Close, Texas State University

Research-based assessments (RBAs), such as the Force Concept Inventory, have played central roles in transforming courses from traditional lecture-based instruction to research-based teaching methods. To support instructors in assessing their courses, the online Learning About STEM Student Outcomes (LASSO) platform simplifies administering, scoring, and interpreting RBAs. Reducing the barriers to using RBAs will support more instructors in objectively assessing the efficacy of their courses and transforming their courses to improve student outcomes. We investigate the extent to which RBAs administered outside of class with the online LASSO platform provided equivalent data to traditional paper and pencil tests administered in class. We used an experimental design to investigate the differences between these two test modes with 1,310 students in three college physics courses. Analysis conducted with Hierarchical Linear Models indicates that the online LASSO platform can provide equivalent data to paper and pencil tests in terms of student participation and performance.

## Upper Division and Graduate

**PST2D01: 9:30-10:15 a.m. Polymer Chain Translocation in Post Array Induced by Arrangement Differ**

Poster – Xingchen Zhang, No.2 Dongnandaxue Road, Nanjing Jiangsu, China 211189 2804602946@qq.com

Zhaohui Wang

Jiahua Lu

We demonstrate that the arrangement of posts has significant effect on the translocation of polymer chains which are embedded in the post arrays by using Monte Carlo algorithm. Moreover, by changing the diameter of the posts, we find that the associated translocation times are strongly affected by the structure of the post array. Hence, a new micro-fabricated device that is used to separate deoxyribonucleic acid (DNA) by molecular weight can be designed using this idea. Moreover, this study can help us to develop a better understanding on the passages of polymers across membranes in nature.

**PST2D02: 10:15-11:00 a.m. Reinforcing Common Themes: Content Alignment of Optics and Analytical Mechanics Curriculums**

Poster – Vanessa M. Preisler, University of La Verne, Department of Physics, 1950 Third St., La Verne, CA 91750; vpreisler@laverne.edu

David Chappell, University of La Verne

There exists common themes, problems, and mathematical techniques throughout the upper-division physics curriculum. Students, however, are prone to overlook these commonalities as each subject is presented separately within a class with usually little overlap between one class and another. We propose a partnership between optics and analytical mechanics courses that aims to highlight common themes and techniques. We show how content between the two classes can be aligned in order to reinforce concepts and demonstrate the connectivity of physics subjects to students.

**PST2D03: 9:30-10:15 a.m. STEM Storytellers: Improving Graduate Students' Oral Communication Skills**

Poster – Shannon D. Willoughby, Montana State University, Department of Physics, Bozeman, MT 59717; shannon.willoughby@montana.edu

Bryce Hughes, Leila Sterman, Chris Organ, Brock LaMeres, Montana State University

Despite the increasing importance of effectively communicating scientific ideas and results to the general public, graduate students in STEM related fields often do not receive extensive opportunities to practice these crucial oral communication skills. This research presents a novel oral communication curriculum that is being developed and tested with STEM graduate students at Montana State University. The program, called the “STEM Storytellers Program,” uses a transformative approach to training graduate students that pulls knowledge from the journalism and performing arts community. Our program has three components: 1) creating jargon-less podcasts; 2) receiving training from an improvisational actor on stage presence; and 3) presenting at “curiosity cafes” to audiences from the general public. We will discuss the program, the curriculum and rubrics we developed, and the recruiting process. We'll also reflect on our initial experiences and offer advice for others interested in offering similar opportunities for graduate students.

**PST2D04: 10:15-11:00 a.m. Student Difficulties with Operators Corresponding to Observables in Dirac Notation**

Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

Even though Dirac notation is used extensively in upper-level quantum mechanics, many advanced undergraduate and graduate students in physics have difficulty in expressing the identity operator and other Hermitian operators corresponding to physical observables in quantum mechanics using the Dirac notation in terms of the outer product of a complete set of orthonormal eigenstates of an operator. To investigate these difficulties, we administered free-response and multiple-choice questions and conducted individual interviews with students after traditional instruction in relevant concepts in advanced quantum mechanics courses. We discuss the analysis of data on the common difficulties found. We thank the National Science Foundation for support.

**PST2D05: 9:30-10:15 a.m. Activities Exploring Potentials and Electric Fields Using Raising Physics to the Surface Manipulatives**

Poster – Robyn L. Wangberg, Saint Mary's University of Minnesota, 700 Terrace Heights Box 32, Winona, MN 55987; rwangber@smumn.edu

Elizabeth Gire, Oregon State University

Aaron Wangberg, Winona State University

Visualizing and understanding relationships between multivariable functions is necessary, but sometimes under-emphasized, in Electricity and Magnetism courses. Raising Physics to the Surface has developed tools that help students discover the deep relationships between the electric field and the corresponding scalar electric potential, and from which understandings of conservative and non-conservative vector fields can grow. At our poster, which shares several classroom activities, you'll be able to explore these concepts as you play with the surfaces.

**PST2D06: 10:15-11:00 a.m. Analogous Patterns of Student Reasoning Difficulties in Introductory Physics and Upper-Level Quantum Mechanics**

Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

Very little is known about how the nature of expertise in introductory and advanced courses compares in knowledge-rich domains such as physics. We develop a framework to compare the similarities and differences between learning and patterns of student difficulties in introductory physics and quantum mechanics. Based upon our framework, we argue that the qualitative patterns of student reasoning difficulties in introductory physics bear a striking resemblance to those found for upper-level quantum mechanics. The framework can guide the design of teaching and learning tools. This work is supported by the National Science Foundation.

**PST2D07: 9:30-10:15 a.m. ComSciCon-Triangle: Science Communication Workshop for Graduate Students**

Poster – Reginald A. Bain, University of Houston, 3507 Cullen Blvd., Room 214, Houston, TX 77204-5004; rabain@uh.edu

Kayleigh O'Keeffe, University of North Carolina at Chapel Hill

The ability of scientists to effectively communicate scientific ideas with a variety of audiences is critical. There is currently a dearth of science communication training opportunities for graduate students in STEM. A series of national and local graduate student-organized science communication workshops for graduate students in STEM called “ComSciCon” is discussed. First founded in 2013 by Harvard astrophysics students, these workshops aim to empower graduate students to be more engaged in communicating science with both the public and with fellow scientists. Workshops include panel discussions, networking opportunities, and hands-on sessions for improving oral/written communication skills. We analyze survey data from from 2015-2017 student attendees to ComSciCon-Triangle, a local workshop held annually in Raleigh-Durham, NC. Attendees feel significantly more confident in their ability to communicate scientific ideas with the public and with scientists, and with submitting a written piece to a popular science publication.

**PST2D08: 10:15-11:00 a.m. Developing an Interactive Tutorial on a Quantum Eraser\***

Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

We developed a quantum interactive learning tutorial (QuILT) on a quantum eraser for students in upper-level quantum mechanics. The QuILT exposes students to contemporary topics in quantum mechanics and uses a guided approach to learning. It adapts existing visualization tools to help students build physical intuition about quantum phenomena and strives to help them develop the ability to apply quantum principles in physical situations. The quantum eraser apparatus in the gedanken (thought) experiments and simulations that students learn from in the QuILT uses a Mach-Zehnder Interferometer with single photons. We also discuss findings from a preliminary in-class evaluation.

\*This work is sponsored by the National Science Foundation.

**PST2D09: 9:30-10:15 a.m. Developing and Evaluating an Interactive Tutorial on Degenerate Perturbation Theory**

Poster – Christof K. Keebaugh, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260-3583; ckk10@pitt.edu

Emily Marshman, Chandralekha Singh, University of Pittsburgh

We discuss an investigation of student difficulties with degenerate perturbation theory (DPT) carried out in advanced quantum mechanics courses by administering free-response and multiple-choice questions and conducting individual interviews with students. We find that students share many common difficulties related to this topic. We used the difficulties found via research as resources to develop and evaluate a Quantum Interactive Learning Tutorial (QuILT) which strives to help students develop a functional understanding of DPT. We discuss the development of the DPT QuILT and its preliminary evaluation in the undergraduate and graduate courses. We thank the NSF for funding.

**PST2D10: 10:15-11:00 a.m. Developing and Evaluating Quantum Mechanics Formalism and Postulates Survey\***

Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

Development of multiple-choice tests related to a particular physics topic is important for designing research-based learning tools to reduce the difficulties related to the topic. We explore the difficulties that the advanced undergraduate and graduate students have with quantum mechanics formalism and postulates. We developed a research-based multiple-choice survey that targets these issues to obtain information about the common difficulties and administered it to undergraduate and graduate students. We find that the advanced undergraduate and graduate students have many common difficulties with these topics. The survey can be administered to assess the effectiveness of various instructional strategies.

\*This work is supported by the National Science Foundation.

**PST2D11: 9:30-10:15 a.m. Development of an Interactive Tutorial on Quantum Key Distribution**

Poster – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506; stdevore@mail.wvu.edu

Chandralekha Singh, University of Pittsburgh

We describe the development of a Quantum Interactive Learning Tutorial (QuILT) on quantum key distribution, a context that involves a practical application of quantum mechanics. The QuILT helps upper-level undergraduate students learn quantum mechanics using a simple two-state system and was developed based upon the findings of cognitive research and physics education research. One protocol used in the QuILT involves generating a random shared key over a public channel for encrypting and decrypting information using single photons with non-orthogonal polarization states, and another protocol makes use of two entangled spin- $\frac{1}{2}$  particles. The QuILT uses a guided approach and focuses on helping students build links between the formalism and conceptual aspects of quantum physics without compromising the technical content. We also discuss findings from a preliminary in-class evaluation. Supported by the NSF.

**PST2D12: 10:15-11:00 a.m. Elementary Quantum Mechanics Formulated with In-Out Symbols**

Poster – Lutz Frank Kasper, University of Education Schwäbisch Gmünd - Physics Department, Josefstr. 9 Schwäbisch Gmünd, Baden-Württemb. 73525 lutz.kasper@ph-gmuend.de

Manuel Daiber, University of Education Schwäbisch Gmünd - Physics Department

This poster shows an approach to elementary quantum mechanics based on Julian Schwingers' symbolism. From a starting point similar to the Stern-Gerlach experiment, we focus on the terms "preparation" (out symbol), "selection" (combined in-out symbol), and "detection" (in symbol). The first step is the symbolic description of classical mechanics. Then students learn about the fundamental differences between classical and quantum mechanics (probability amplitude). Thoroughly we go through the symbolic description of the double-slit experiment and can draw fundamental mathematical conclusions. While addressing the probability interpretation and descriptions of interference phenomena we avoid any pictures of particle paths. First evaluations show that the course can be conducted on a High-School level and in physics teacher education as well.

**PST2D13: 9:30-10:15 a.m. Expectations and Experiences in a Modern Physics Laboratory Course**

Poster – Helen M. Cothrel, Eastern Michigan University, 104 Roosevelt Hall Ypsilanti, MI 48197; helen.cothrel@gmail.com

Jonathan Skuza, Eastern Michigan University

Modern physics is a crucial course due to its context as a bridge between the introductory level and quantum mechanics. Laboratory courses in modern physics are under scrutiny due to a dearth of evidence that their benefits to students—especially regarding content knowledge—outweigh the resources needed to maintain them. As such, it is worth questioning whether it is justifiable to continue to offer labs along with lecture in modern. This study examines students' experiences in a modern physics lab through beginning- and end-of-semester interviews to learn what is meaningful or valuable (or not) to them about the lab. I will expand upon the results presented in my contributed talk to show that students' ideas about the modern physics lab extend beyond content knowledge.

**PST2D14: 10:15-11:00 a.m. Helping Students Learn Thermo with Raising Physics to the Surface**

Poster – Elizabeth Gire, Oregon State University, 301 Weniger Hall, Corvallis, OR 97331-8574; giree@oregonstate.edu

Aaron Wangberg, Winona State University

Robyn Wangberg, St. Mary's University of Minnesota

Jonathan Alfson, Oregon State University

Thermodynamics is notoriously hard to learn. One of the challenges is that thermal systems are described by multivariable functions whose variables are non-spatial, functions of state, and are themselves partial derivatives... and they have multiple dependent variables! The Raising Physics instructional materials are designed to help learners understand the mathematics of thermodynamics. These instructional materials feature 3D surfaces and contour plots to help students visualize functions of two variables and their derivatives. The surfaces represent real physical systems in order to emphasize the math-physics connection and help students build intuitions about the behaviors of these systems. At our interactive poster, you'll have a chance to do our activities and play with the surfaces.

**PST2D15: 9:30-10:15 a.m. Improving Students' Understanding of Lock-in Amplifiers**

Poster – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506 [stdevore@mail.wvu.edu](mailto:stdevore@mail.wvu.edu)

Alexandre Gauthier, Jeremy Levy, Chandralekha Singh, University of Pittsburgh

A lock-in amplifier is a versatile instrument frequently used in physics research. However, many students struggle with the basic operating principles of a lock-in amplifier which can lead to a variety of difficulties. To improve students' understanding, we have developed and evaluated a research-based tutorial which utilizes a computer simulation of a lock-in amplifier. The tutorial is based on a field-tested approach in which students realize their difficulties after predicting the outcome of simulated experiments involving a lock-in amplifier and check their predictions using the simulated lock-in amplifier. Then, the tutorial guides and helps students develop a coherent understanding of the basics of a lock-in amplifier. The tutorial development involved interviews with physics faculty members and graduate students and iteration of many versions of the tutorial with professors and graduate students. The student difficulties and the development and assessment of the research-based tutorial are discussed. Supported by the NSF.

**PST2D17: 9:30-10:15 a.m. Investigating Intrinsically Localized Vibrations in Crystalline Lattices Using Van-Hove Singularities**

Poster – Benjamin A. Agyare, Stockton University, 101 Vera King Farris Drive, Galloway, NJ 08205; [Benjamin.Agyare@stockton.edu](mailto:Benjamin.Agyare@stockton.edu)

Peter Riseborough, Temple University

Sodium Iodide has a rock salt structure. Intrinsically Localized Modes (ILMs) have supposedly been observed in NaI but only for wave-vectors at the corner of the 3-D Brillouin Zone. It has been suggested that, for high-symmetry  $q$  vectors, several van Hove singularities may converge at one critical energy producing a large peak in the two-phonon density of state spectrum and giving rise to ILMs with these  $q$  values. First, we fit the experimentally determined acoustic and the optic phonon modes using a nearest neighbor and a next-nearest neighbor force constants. We find that the two-phonon density of states, for fixed  $q$  exhibits non-divergent van Hove singularities. The energies of these features vary as  $q$  is varied and we have identified the  $q$  values at which the two-phonon density of states is enhanced. We intend to introduce anharmonic interactions and examine if it can bind the two-phonon excitations to produce a quantized ILM.

**PST2D18: 10:15-11:00 a.m. Investigating Transfer of Learning in an Upper-Level Quantum Mechanics Course\***

Poster – Alexandru Maries, University of Cincinnati, 3405 Telford St., Cincinnati, OH 45220; [United States mariesau@ucmail.uc.edu](mailto:United States mariesau@ucmail.uc.edu)

Chandralekha Singh, University of Pittsburgh

Transfer of learning from one context to another is considered a hallmark of expertise. Physics education research has often found that students have great difficulty transferring learning from one context to another. We examine upper-level and graduate students' facility with questions about the interference pattern in the double-slit experiment with single photons and polarizers in various orientations placed in front of one or both slits. Answering these questions correctly in the context of the double-slit experiment requires transferring learning about concepts from the context of a tutorial on Mach-Zehnder Interferometer (MZI) with single photons and polarizers in various paths of MZI. We discuss the extent to which students who worked through the MZI tutorial were able to transfer what they learned in that context to another context involving the double-slit experiment.

\* Work supported by the National Science Foundation

**PST2D19: 9:30-10:15 a.m. Polymer Chain Translocation in Post Array Induced by Arrangement Differ**

Poster – Zhaohui J. Wang, No. 2 Dongnandaxue Road, Nanjing Jiangsu, China 211189 China [845205357@qq.com](mailto:845205357@qq.com)

Xingchen Zhang

Jiahua Hua

We demonstrate that the arrangement differs of posts have significant effect on the translocation of polymer chains which are embedded in the post arrays by using Monte Carlo algorithm. Moreover, by changing the diameter of the posts, we find that the associated translocation times are strongly affected by the structure of the post array. Hence, a new micro-fabricated device that is used to separate deoxyribonucleic acid (DNA) by molecular weight can be designed using this idea. Moreover, this study can help us to develop a better understanding on the passages of polymers across membranes in nature.

**PST2D20: 10:15-11:00 a.m. Polymer Chain Translocation in Post Array Induced by Arrangement Differ**

Poster – Jiahua Lu, No. 2 Dongnandaxue Road, Nanjing Jiangsu, China 211189 China [781923390@qq.com](mailto:781923390@qq.com)

Zhaohui Wang,

Xingchen Zhang,

We demonstrate that the arrangement differs of posts have significant effect on the translocation of polymer chains which are embedded in the post arrays by using Monte Carlo algorithm. Moreover, by changing the diameter of the posts, we find that the associated translocation times are strongly affected by the structure of the post array. Hence, a new micro-fabricated device that is used to separate deoxyribonucleic acid (DNA) by molecular weight can be designed using this idea. Moreover, this study can help us to develop a better understanding on the passages of polymers across membranes in nature.

**PST2D21: 9:30-10:15 a.m. Student Difficulties with Finding the Corrections to the Energy Spectrum of the Hydrogen Atom for the Strong and Weak Field Zeeman Effects Using Degenerate Perturbation Theory**

Poster – Christof K. Keebaugh, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260-3583; [ckk10@pitt.edu](mailto:ckk10@pitt.edu)

Emily Marshman, Chandralekha Singh, University of Pittsburgh

We discuss an investigation of student difficulties with the corrections to the energy spectrum of the hydrogen atom for the strong and weak field Zeeman effects using degenerate perturbation theory. This investigation was carried out in advanced quantum mechanics courses by administering written free-response and multiple-

choice questions and conducting individual interviews with students. We discuss the common student difficulties related to these concepts, which can be used as a guide for creating learning tools to help students develop a functional understanding of concepts involving the corrections to the energy spectrum due to the Zeeman effect. We thank the NSF for support.

**PST2D22: 10:15-11:00 a.m. Student Difficulties with Finding the Fine Structure Corrections to the Energy Spectrum of the Hydrogen Atom Using Degenerate Perturbation Theory**

Poster – Christof K. Keebaugh, 3941 O'Hara St., Pittsburgh, PA 15260-3583; ckk10@pitt.edu  
Emily Marshman, Chandralekha Singh, University of Pittsburgh

We discuss an investigation of student difficulties with the fine structure corrections to the energy spectrum of the hydrogen atom in the context of degenerate perturbation theory (DPT). The investigation was carried out in advanced quantum mechanics courses by administering free-response and multiple-choice questions and conducting individual interviews with students. We discuss the common student difficulties related to these concepts. These findings can provide guidelines for creating learning tools to help students develop a functional understanding of concepts involving the fine structure corrections to the energy spectrum of a hydrogen atom. We thank the NSF for support.

**PST2D23: 9:30-10:15 a.m. Student Difficulties with the Representation in Which an Operator Is Diagonal In the Context of Degenerate Perturbation Theory**

Poster – Christof K. Keebaugh, 3941 O'Hara St., Pittsburgh, PA 15260-3583; ckk10@pitt.edu  
Emily Marshman, Chandralekha Singh, University of Pittsburgh

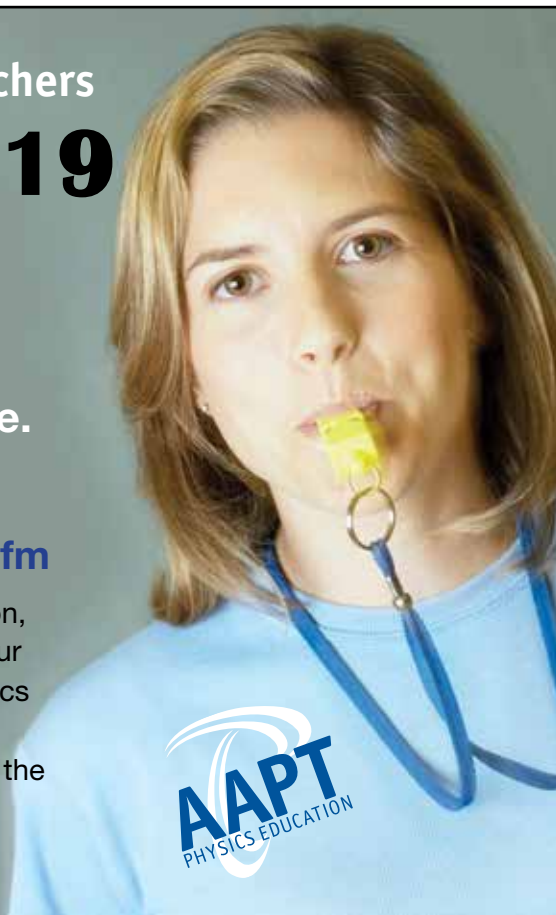
We discuss an investigation of student difficulties with the representation in which a Hermitian operator corresponding to a physical observable (e.g., the Hamiltonian operator corresponding to energy) is diagonal in the context of degenerate perturbation theory involving the Zeeman effect in the hydrogen atom. This investigation was carried out in advanced quantum mechanics courses by administering written free-response and multiple-choice questions and conducting individual interviews with students. We discuss the common student difficulties related to these concepts, knowledge of which can be useful for developing research-validated learning tools. We thank the NSF for support.

# American Association of Physics Teachers **PHYSICSBOWL 2019**

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**Steven Rolston**  
University of Maryland

## The Coming Quantum Revolution

The Information Revolution was built on the insights of quantum physics — semiconductor properties, lasers, and magnetism. But these did not require considering the things about quantum mechanics that keep people up at night - superposition, measurement, and entanglement. Through technological advances of the last twenty years, we can now trap individual atoms and ions, create superconducting circuits that act as single quantum bits, and create spins embedded in solid state materials with coherence times of seconds. Adding in the insights of information and computer science, we are poised for a second quantum revolution — one where the “weird” features of quantum mechanics will be exploited. Potential applications include quantum computers and simulators, quantum-enhanced sensors, and quantum networks. Countries are beginning to invest billions, and companies large and small are starting quantum efforts. This talk will highlight the science, the technology, the hype, and the future of the quantum revolution to come.



**Evangeline J. Downie**  
George Washington University

## The Proton Radius Puzzle

The Proton Radius Puzzle is the difference between the radius of the proton when measured with electrons, and that measured with muons. Its potential resolutions could be very exciting, include beyond-standard-model physics. The puzzle has resulted in several papers in Science and Nature, and much popular media interest. It began in 2010 with an ultra-precise radius measurement by the CREMA collaboration using muonic hydrogen, which produced a proton radius result roughly 7 standard deviations away from the accepted value. This caused a flurry of theory development, new experiments, and much thought and discussion. The radius puzzle remains unresolved to this day, with many new experiments proposed and under development and hotly debated theories. We will give an overview of the Puzzle, its potential implications and resolutions, and an overview of the ongoing experimental efforts. to understand the discrepancy in a quantity of relevance for many areas of physics.

### Session GA: PER: Informal Settings, Accessibility, and Inclusion

**Location:** Meeting Room 13/14

**Sponsor:** AAPT/PER

**Time:** 1–2:30 p.m.

**Date:** Wednesday, August 1

**President:** Lindsay Owens

#### GA01: 1:00-1:10 p.m. Informal Teaching Is Integral to Shaping Physics Students' Identities

*Contributed – Brean Prefontaine, Michigan State University, 1634 Cambria Dr. Apt. 3, East Lansing, MI 48823-2398; prefont4@msu.edu*

*Kathleen Hinko, Michigan State University*

*Claudia Fracchiolla, University College Dublin*

In addition to research and classes, physics students may choose to participate in informal physics teaching experiences; however, these programs are understudied as part of the physics student experience. We investigate university educators' (UEs) negotiation of physics identity after they participate in an informal program for youth as part of the Science Theatre group at Michigan State University or the PISEC afterschool program at the University of Colorado. We hypothesize that UEs' physics identity is reshaped by the interactions and experiences they have in these programs. Interviews have been analyzed with a Community of Practice framework to understand the UEs experiences as they negotiate their memberships in the outreach and scientific communities of practice. Preliminary findings indicate these experiences support students by (1) providing an outlet for teaching, (2) creating meaningful relationships within peer groups, and (3) allowing UEs to deliver physics content in an expert role with immediate feedback.

#### GA02: 1:10-1:20 p.m. Determining the Landscape of Informal Physics in the United States

*Contributed – Kathleen A. Hinko, Michigan State University, 919 E. Shaw Ln., East Lansing, MI 48825; hinko@msu.edu*

*Noah D. Finkelstein, University of Colorado Boulder*

Physics outreach is a ubiquitous endeavor undertaken by individual physicists, physics students, and broader physics institutions. However, we currently have no means to leverage these collective efforts or to understand the full impact on participants. To do so, it is imperative that as a physics education community, we are able to systematically describe the “who, where, when, how, and why” of the informal physics programs that we engage in. To this end, we will discuss a new project

that seeks to empirically determine the landscape of informal physics supported by academic and research institutions in the United States. Survey, interview, and site visit data will be collected and analyzed to 1) produce a taxonomy of informal physics programs and 2) reveal the structural and cultural practices that support these environments. We will share preliminary efforts and also put forth a call to join the project and contribute to the study.

**GA03: 1:20-1:30 p.m. Impacts of Educational Structures on Pedagogical Approaches in Informal Learning**

*Contributed – Michael B. Bennett, University of Colorado Boulder, 440 UCB, Boulder, CO 80309; michael.bennett@colorado.edu*

*Brett Fiedler, Noah D. Finkelstein, University of Colorado Boulder*

Physicists often engage in teaching in informal environments, but research on their means of engagement in these settings is fairly nascent. A 2016 study of CU Boulder's Partnerships for Informal Science Education in the Community (PISEC) outreach program categorized so-called "pedagogical modes" utilized by the program's "University Educators" (UEs) during teaching. Our study aims to understand the factors that contribute to UEs' tendencies towards one or more of these modes. We surveyed UEs for their pre-semester preferences towards the modes, then recorded their activity over the semester, analyzing it to determine where their stated preferences and enacted preferences were in agreement or conflict. We will discuss findings and their potential relation to the activities, norms, and structures of PISEC, exploring how the program promotes -- or constrains -- UEs' freedom of pedagogical choice. The results of this study have implications for teacher training in both informal and formal settings.

**GA04: 1:30-1:40 p.m. A Student-Driven Definition of Productivity in Informal Learning**

*Contributed – Brett L. Fiedler,\* University of Colorado at Boulder, 440 UCB, Boulder, CO 80309-0440; brett.fiedler@colorado.edu*

*Paul Reynerson, Michael B. Bennett, Noah D. Finkelstein, University of Colorado at Boulder*

*Claudia Fracchiolla, University College Dublin*

Informal science environments provide unique affordances over formal settings because they are frequently structured around participants' ability to choose and control what they learn or how they engage. This freedom allows participants to navigate the subject matter in a self-directed manner and to form their own objectives for the program. Because students may set their own course, however, evaluating student productivity in these settings is not straightforward. To address this issue, we have studied student productivity by interviewing participants in the Partnerships for Informal Science Education in the Community (PISEC) outreach program. Assessment of student objectives for participation in the program from the interviews is compared to their in situ behavior. Evidence for and examples of a student-objective driven definition of productivity in PISEC and implications for outreach program design will be presented.

\*Sponsored by Michael B. Bennett

**GA05: 1:40-1:50 p.m. Demonstration Recognition Among 9th-12th Grade Students: A Program Effectiveness Study**

*Contributed – Patrick R. Morgan, Michigan State University, 755 Science Rd., East Lansing, MI 48824; morgan@pa.msu.edu*

The Science Theatre program is a student outreach organization at Michigan State University. Since 2011, they have been visiting schools in the Upper Peninsula during the MSU Spring Break. These schools are only visited once a year, and otherwise have little or none science outreach exposure. In 2017, a survey was conducted among 157 high school students at St. Ignace Senior High School to look for any form of demonstration recognition. The goal was to find evidence that these students, who have seen the program once each year, would be able to recognize and identify some of the demonstrations. What we found was a much greater level of recognition than anticipated, along with a recognition of terminology and topics discussed, suggesting that there is a form of learning. This presentation will go over the results of this survey, what the takeaways are, and the future of this type of program.

**GA06: 1:50-2:00 p.m. Implementing Universal Design for Learning Aligned Strategies in STEM Courses**

*Contributed – Westley James, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816; westley.d.james@knights.ucf.edu*

*Jillian Schreffler, Eleazar Vasquez III, Jacquelyn J. Chini, University of Central Florida*

When planning our pedagogy, it is critical that we recognize the variability amongst learners in our courses, especially those traditionally under-served, such as students with disabilities (SWDs). To support all students on the ability spectrum, instructors from Studio physics courses and inquiry-based chemistry labs were trained in the Universal Design for Learning (UDL) framework. These courses already implement evidence-based practices; however, accessibility based on learner preference/ability had yet to be considered and purposefully supported. The UDL framework recognizes the variability in all learners through three guiding principles: multiple means of representation, expression, and engagement. As a result of this training, instructors chose and implemented strategies specifically focused on increasing accessibility to learning. A sample of these strategies will be presented, along with how they increase accessibility through the lens of the UDL framework.

**GA07: 2:00-2:10 p.m. Using Universal Design for Learning to Prepare for Learner Variation in Postsecondary Physics**

*Contributed – Jacquelyn J. Chini, University of Central Florida, 4111 Libra Drive, Orlando, FL 32816; jchini@ucf.edu*

*Erin Scanlon, Westley James, Jillian Schreffler, Eleazar Vasquez, University of Central Florida*

Learners vary across multiple dimensions in the skills, needs, and interests they bring to learning. For example, 10% of undergraduate students identify as disabled and a growing proportion of undergraduate students speak English as a second language. The challenges students in these populations face in learning physics are also faced to varying degrees by their classmates. Universal Design for Learning (UDL) provides a framework for curriculum development that provides all students equal opportunities to learn. The UDL framework is composed of three overarching guidelines (Provide multiple means of representation, Provide multiple means of action and expression, and Provide multiple means of engagement) and 31 finer-grained checkpoints. As a community, physics education researchers have not frequently focused on some aspects of diversity. However, we have developed some shared goals for student-centered active learning instructional strategies. We will present likely areas of overlap and disconnect between these goals and the UDL framework.

**GA08: 2:10-2:20 p.m. Investigation of Introductory Physics Curricula Through an Accessibility Lens**

*Contributed – Erin Scanlon, University of Central Florida, 4111 Libra Drive, Orlando, FL 32816; erin.scanlon@ucf.edu*

*Westley James, Jillian Schreffler, Eleazar Vasquez, Jacquelyn J. Chini University of Central Florida*

To investigate how well we, as a community, support variations in learners' skills, interests, and needs, we analyzed reformed, research-based introductory physics curricular materials through an accessibility lens, operationalized through the Universal Design for Learning (UDL) framework. The UDL framework proposes three guidelines and 31 finer-grained checkpoints that support curriculum development that provides all students equal opportunities to learn. Overall, we found little alignment between the physics curricula and the UDL guidelines. This is to be expected because the curricular materials were not designed explicitly to align with the

UDL framework. However, we also found ways in which the curricular materials aligned with the framework. Specifically, these curricular materials: supported planning and strategy development; fostered collaboration and community; clarified vocabulary and symbols; and highlighted patterns, critical features, big ideas, and relationships. The ways in which the curricular materials currently support diverse learners and suggestions for future curricula will be discussed.

**GA09: 2:20-2:30 p.m. Non-Traditional Approaches for Teaching Physics to Non-Traditional Students**

*Contributed – Russell R. Ceballos,\* Chicago State University, 9501 South King Dr., Chicago, IL 60628 rcebal20@csu.edu*

It is extremely difficult to determine the appropriate methods and strategies required to help students who have not had the proper educational background and/or resources to compete in the cutthroat environment of higher education. In this talk I wish to address why this is particularly true for physics students, as well as what strategies seem to be advantageous. Specifically, I would like to discuss what it would look like to reform our physics and mathematics curriculum at Chicago State University so as to facilitate the success of our students using a more streamlined, yet more mathematically rigorous program of study. I find that students are more amenable to learning advanced mathematical concepts and techniques, so long as they are rewarded with an enhanced ability to understand the material at hand, as well as solve a greater variety of difficult problems.

\*Sponsored by Dr. Mel Sabella

**Session GB: PER: Groupwork, Interactions, and the Culture and Nature of Science**

**Location:** Meeting Room 8/9 **Sponsor:** AAPT/PER **Time:** 1–2:30 p.m. **Date:** Wednesday, August 1 **President:** Steven Wolf

**GB01: 1:00-1:10 p.m. Denoting Leadership Actions and Traits in Group Work**

*Contributed – Kristina Griswold, Michigan State University, 129 Highland Ave., East Lansing, MI 48823; kgriswold28@gmail.com*

*Daryl McPadden, Marcos Caballero, Paul Irving, Michigan State University*

P<sup>3</sup> is an introductory mechanics based physics class at MSU that replaces lectures with a PBL learning environment. To promote the development of group based practices, students all receive group and individual feedback at the end of each week. The groups are composed of four students, one of which often takes on the role of being the group's "leader." Developing leadership-based skills is a specific learning goal of the P<sup>3</sup> learning environment and the goal of this research is to examine what actions/traits students in P<sup>3</sup> demonstrate while working in their group. The initial phase of this study examines multiple pieces of literature to identify possible characteristics and behaviors that may present themselves in potential leaders. In this presentation, we present the initial phase of our code book and a preliminary example of how it can be used to denote leader(s) and followers in our case study.

**GB02: 1:10-1:20 p.m. Evidence for Effective Group Work in Studio Physics**

*Contributed – Robynne M. Lock, Texas A&M University-Commerce, Department of Physics and Astronomy, Commerce, TX 75429; robynne.lock@tamuc.edu*

*Melanie Schroers, Trever Bench, Nicole Gentry, Texas A&M University-Commerce*

Group work in environments such as studio physics, or SCALE-UP, has been promoted as a method of improving students' conceptual understanding and problem-solving skills. However, strategies for creating effective groups and teaching students to work together effectively in university physics classes have not been sufficiently tested. In order to study these strategies, we must first determine what constitutes an effective group and what constitutes an ineffective group. We recorded video of groups in the introductory calculus-based physics sequence at Texas A&M University-Commerce over the course of several semesters. Groups were recorded completing tutorials, problem-solving activities, and labs. In each class section, the instructor suggested a "good" group and a "bad" group to be recorded. Video data has been coded using epistemological framing, and social network analysis has been conducted. We present evidence for what constitutes effective group work.

**GB03: 1:20-1:30 p.m. Studying Community Development: A Network Analytical Approach**

*Contributed – Christopher Hass, University of Calgary, 3452 62 Ave S.W., Calgary, AB T3E 5J3 Canada chris.hass@shaw.ca*

*Pierre P.A. Ouimet, University of Regina*

*Katarzyna E. Pomian, Mary-Bridget Kustus, DePaul University*

*Florian Genz, University of Cologne*

In a participationist learning framework, the development and evolution of a community is a key component of learning. We set out to use network analysis for studying community dynamics based on classroom video data. By recording interactions between students as network ties, and classifying different types of interactions, we are able to generate networks which give us insight into how different types of interactions aid in community development and evolution. Specifically we looked to see how the frequency of task oriented, topical (related to STEM or the program), and social interactions evolved over the duration of a 2 week pre-matriculation metacognition program. Understanding the dynamics involved in building a working community will better equip us to support student community development and encourage learning.

**GB04: 1:30-1:40 p.m. Investigating Student Collaboration Using Exponential Random Graph Models**

*Contributed – James E. Wells, W. M. Keck Science Dept of Claremont Mckenna, Pitzer, and Scripps Colleges, 925 N. Mills Ave., Claremont, CA 91711-5916; jwells@kecksci.claremont.edu*

Student collaboration is a powerful technique for learning physics. Students may collaborate formally, in class or on a project with assigned groups, or informally, usually in study groups outside of class. The extent of collaboration between students in a given class depends on the characteristics of individual students, as well as the forces that govern social interactions. The interactions between students can be modeled as a network, with each student as a node and links between nodes indicating student collaboration. Exponential random graph models (ERGMs) are a logistic-regression-like tool to measure how the probability of a link forming between two nodes depends on the node characteristics and the larger pattern of links within the network. This study uses ERGMs to show that the instructor-assigned, in-class groups in an introductory physics course significantly affect students' informal collaborations outside of class, but this effect changes over the length of the semester.

**GB05: 1:40-1:50 p.m. Examining Group Work in Modeling Physics through the Lens of Social Interdependence Theory**

*Contributed – Miguel Rodriguez, Florida International University, 3105 Kingston Ct., West Palm Beach, FL 33409; mrodr1106@fiu.edu*

*Geoff Potvin, Florida International University*

Modeling Instruction is a well known physics curriculum which relies heavily on cooperative learning between students, deriving from social constructivist theories of learning. In the current study, we focus on interpreting student group engagement using the lens of social interdependence. Social Interdependence Theory is a framework for understanding how groups of individuals may (or may not) cooperate towards common learning goals. We will present an analysis of two particular sub-constructs of social interdependence theory: students' efforts to succeed and the development of positive inter-relationships. This analysis will consider multiple sources of data including in-class observations, student interviews and survey data of constructs related to, and predictive of, positive social interdependence.

**GB06: 1:50-2:00 p.m. Social Positioning and Consensus Building in “Board” Meetings With Disagreements**

*Contributed – Brant E. Hinrichs, Drury University, 729 N. Drury Lane, Springfield, MO 65802; bhinrichs@drury.edu*

*David T. Brookes, California State University, Chico*

*Jake Nass, Drury University*

This talk describes a whole-class whiteboard meeting and analyzes several examples from a college calculus-based introductory physics course and junior-level E&M course taught using modeling instruction. Classes were divided into 3-6 groups of 2-4 students each. Each group created a solution to the same problem on a 2'x 3' whiteboard. The groups then formed a large circle in the center of the classroom with their whiteboards resting against their knees facing in to the rest of the group. The instructor was outside the circle and interjected rarely. Examples are given of conversations where students did and did not overcome sharp disagreements to eventually reach whole-class consensus. We examine how social positioning contributed to students either successfully examining and resolving different ideas or failing to do so. We test the hypothesis that students who “hedged” their statements seemed to “open up” the space for discussion, while those who were more direct seemed to “close” it down.

**GB07: 2:00-2:10 p.m. Summary Lecture as Delay Organizer of Knowledge? A Discipline-Culture Approach**

*Contributed – Ehud Goren,\* The Hebrew University of Jerusalem Israel, Givat Ram Campus, Science bld #9, Ramat HaSharon, Israel 4711201 Israel ehud.goren@mail.huji.ac.il*

*Igal Galili, The Hebrew University of Jerusalem Israel*

The study proposes a new educational tool – a delay organizer to support meaningful learning of physics. In particular, we emphasized a theory-based knowledge of physics and a hierarchical structure of physical theory. The instruction was embedded into a summary lecture which reviewed the major content of mechanics exemplifying nucleus, body and periphery of the theory of classical mechanics. The goal was to promote students' cultural content knowledge in this domain of school physics. The study included construction of a summary lecture and the assessment of its experimental application in high school (11th 12th grades) and educational college (pre-service science teachers of science). Some results of qualitative and quantitative assessment are presented. They indicated the efficacy of such intrusion and its positive impact on students' holistic knowledge and conceptual understanding. Besides, the instruction caused increasing of student interest to the subject matter presented in conceptual variation expanding the traditional disciplinary curriculum.

\*Sponsored by Prof. Igal Galili

**GB08: 2:10-2:20 p.m. Refinement the Oversimplified Depiction of Nature of Science – Physics Perspective**

*Contributed – Igal Galili, The Hebrew University of Jerusalem, Givat Ram Campus, Science bld #9, Jerusalem, 91904 Israel; igal.galili@mail.huji.ac.il*

Our study considers the short list of nature of science (NOS) features frequently published and widely known in science education discourse. It is argued that the refinement of the claims of that list may enrich and sometimes reverse them. The refinement drawing on the history and philosophy of physics shows necessity to address a span of variation of each particular aspect of NOS, illustrate it with real historical events in order to adequately represent the subject. Another implication is the central role of physics educators who, facing various strong claims often cannot afford to identify themselves with a single stance but need a representative variation of the traditional claims regarding NOS in order to save the original spirit of physics in present educational context. Using knowledge organization in a discipline-culture structure and addressing plural scientific methodology may be helpful in actual teaching and learning of physics at schools.

**GB09: 2:20-2:30 p.m. Teacher Knowledge and their Use of Representations During Energy Instruction**

*Contributed – Robert C. Zisk, Rutgers University, 10 Seminary Pl., New Brunswick, NJ 08901; robert.zisk@gse.rutgers.edu*

*Eugenia Etkina, Drew Gitomer, Rutgers University*

The knowledge teachers have for teaching a particular subject should be reflected in their instructional practice. In teaching of energy, representations are an important tool when analyzing energy processes and related phenomena. In this talk I will describe two teachers' understanding of the purpose and use of representations during energy instruction. I will then provide examples from the assignments and assessments that each teacher used during their unit on energy in mechanics to describe how their knowledge of representations is reflected in how they expect students to use such representations in the tasks that they design for instruction.

## Session GD: Panel – Council on Undergraduate Research

Location: Marriott Marquis - Cherry Blossom Sponsor: AAPT Time: 1–3 p.m. Date: Wednesday, August 1 President: Brian Pyper

### GD01: 1:00-3:00 p.m. Physics and Astronomy Opportunities with the Council on Undergraduate Research

Panel – Michael Jackson, Millersville University of Pennsylvania, 50 E. Frederick Street, Rm. 206 Caputo Hall, Millersville, PA 17551; mjackson@millersville.edu  
Toni Sauncy, Texas Lutheran University

Duncan McBride, National Science Foundation (Retired)

The Council on Undergraduate Research (CUR), founded in 1978, is a multidisciplinary organization whose mission is to support and promote high-quality undergraduate student-faculty collaborative research and scholarship. Individual members are organized by divisions with the Physics and Astronomy (P&A) Division one of the oldest in the organization, second only to the Chemistry Division. Consequently, there are numerous opportunities for P&A faculty and students to participate in and benefit from the activities CUR offers. CUR currently has about 13,000 individual members and 700 institutional members, mostly colleges and universities, in several membership categories. CUR's Enhanced member institution classification provides free individual membership to any faculty, student, or staff member at the institution, thus providing an easy way for P&A faculty, staff, and students to become involved with CUR. Professional development is a key feature to several of CUR's programs. Along with CUR Dialogues and CUR Institutes that offer a range of faculty professional development programs, CUR offers a variety of consulting services, such as program reviews and on-campus institutes as well as department and faculty awards. For students, the organization hosts its annual Posters on the Hill event in Washington DC, the REU Symposium, and the National Conference on Undergraduate Research (NCUR). NCUR creates a unique environment for multi- and inter-disciplinary interactions; celebrating and promoting undergraduate student achievement, providing models of exemplary research and scholarship along with professional development opportunities for students. Finally, the P&A Division has directly supported its members through a variety of initiatives including student travel grants, a multi-university NSF-REU program, and a faculty mentor award. During this presentation, panelists will provide an overview of these and other programs CUR offers, including their current NSF-funded IUUSE proposal on integrating research into the curriculum (CUR Transformations Project, Grant no. 1625354). Panelists will answer questions about how these programs can benefit the professional growth of P&A faculty as well as their students. Finally, panelists will lead a discussion guiding participants to consider ways of integrating research into the curriculum.

## Session GF: Integrating History of Science into Physics Courses II

Location: Marriott Marquis - Dogwood Sponsor: AAPT Time: 1–1:40 p.m. Date: Wednesday, August 1 President: Tom Carter

### GF01: 1:00-1:10 p.m. History as Means for Teaching Introductory Quantum Physics

Contributed – Jill A. Macko, Eastern Nazarene College, 23 East Elm Ave., Quincy, MA 02170-2999; jill.macko@enc.edu

In this talk I will discuss our experience at ENC in teaching introductory Quantum Physics via the history of its development, working from the dominance of Maxwell's electromagnetic waves to the discoveries of Einstein's photons and Bohr's quantized electronic energies and finally to the Bohr-Einstein debates and the dominance of the Copenhagen interpretation of the wave function. By including the history of science in our introductory quantum physics course, we have experienced benefits in the students' learning such as a fuller conceptual understanding of Quantum Physics (versus just "plug-and-chug" skills) and a deeper practical understanding of the Nature of Science. We will also discuss our methods of addressing the various challenges of integrating History of Science in the context of a "pure science" course.

### GF02: 1:10-1:20 p.m. The Invention of Public Radio at the UW-Madison Physics Department, 1917-1919

Contributed – James Reardon, UW-Madison, Department of Physics, 1150 University Ave., Madison, WI 53706; jcreardon@wisc.edu

From April 1917-March 1919 Prof. Earle Terry of the UW Physics Department was able to continue research in wireless voice telephony—what we would now call AM radio—while all through the rest of the world, non-military radio research was halted by World War I. By the end of this time, he and graduate student Cyril Jansky were able to make triode vacuum tubes capable of dissipating more than 50 W, allowing his station 9XM to transmit voice intelligible at a range of 130 miles. Terry and Jansky freely shared their work with researchers at other universities, which contributed to the proliferation of college and university radio stations in the 1920s, the ancestors of what we now know as public radio. Our attempt to recreate the original 9XM transmitter has awoken huge interest in our Physics Department; the vacuum triodes we have made are a perfect vehicle for studying Richardson's law and the Child-Langmuir law in our upper-level undergraduate laboratory.

### GF03: 1:20-1:30 p.m. The Nature of Science Lesson Should Not Be One-And-Done

Contributed – Paul Ashcraft, Mercyhurst University, 501 E 38th St., Erie, PA 16546; pashcraft@mercyhurst.edu

Joseph A. Johnson, Mercyhurst University

Students often tune out the introductory lesson where the Nature of Science and the Scientific Method are discussed. However, repeated emphasis and experiential learning on how scientific theories evolved from better measurements changing our hypotheses can encourage students to produce new findings through their own research. Examples from the history of science can be incorporated into curricula to show both evolutionary and revolutionary changes. Suggestions for implementation through lecture, guided inquiry, discussion boards or even historical movies will be presented.

### GF04: 1:30-1:40 p.m. Role Playing Games in College Physics Classrooms

Contributed – Adria C. Updike, Roger Williams University, 53 Foxhill Ave., Bristol, RI 02809; aupdike@rwu.edu

While role-playing games have been employed by instructors in many fields as valuable teaching tools, many of these games have been aimed at humanities classrooms. The Reacting to the Past (RTTP) pedagogy for role playing using historical events is well-established active-learning method of engaging students in historical events, and offers a growing number of STEM games suitable for physics classrooms. These games come pre-packaged with inexpensive published texts for the students and instructor manuals for teachers. The games require students to engage with both the science and the history to construct arguments, write papers and give talks from the point of view of historical characters in an attempt to "win" the game. Students gain valuable insight into the intersection of science with society through this pedagogy. I will discuss my experience using these games in undergraduate physics classes, particularly in those aimed at a more general audience.

## Session GG: Models for Integrating Computation into Undergraduate Physics

**Location:** Marriott Marquis - Scarlet Oak    **Sponsor:** Committee on Educational Technologies    **Co-Sponsor:** Committee on Physics in Undergraduate Education  
**Time:** 1–2:50 p.m.    **Date:** Wednesday, August 1    **President:** Marie Lopez del Puerto

### GG01: 1:00-1:30 p.m. Enhancing the Undergraduate Physics Curriculum with Computation

*Invited – Kelly Roos, Bradley University, 1501 West Bradley Ave., Peoria, IL 61625; rooster@bradley.edu*

I believe (hope?) that in this contemporary era, wherein the vast majority of professional physicists spend a vast amount of each day interacting with a silicon unit, there is general agreement amongst physics faculty that the inclusion of computational activities will positively enhance the undergraduate physics curriculum. However, the elevation of computational methods in undergraduate courses to the status of a widely-used, viable tool that completes the three-legged stool approach to physics education (the other two legs are analytical theory and experiment), is still well under development. I will describe how the inclusion of computational activities in individual courses can expand the range of coverage of physics topics, and can lead to opportunities for students to engage in learning that would not be accessible through the traditional approach of non-computational, analytical theory alone.

### GG02: 1:30-1:40 p.m. An Holistic Integration of Computational Modeling in Undergraduate Physics

*Contributed – Brandon R. Lunk, Texas State University, 749 N. Comanche St.; RFM bldg 3240, San Marcos, TX 78666; b\_l150@txstate.edu*  
*David Donnelly, Hunter Close, Kushal Das, Texas State University*

Virtually all physics graduates will need to be able to program or otherwise leverage computational tools to solve problems whether they go into academia or industry. Indeed, the recent “Phys21: Preparing Physics Students for 21st Century Careers” report [1] charges physics departments and educators with providing students access to an environment that can enable them to develop programming and other computational skills. In order to address the recommendations of the Phys21 report at Texas State University, we have begun a holistic integration of computation throughout the major degree plan starting with the introductory sequence and extending through upper-level courses. We will discuss the goals that we are forwarding, the instructional and scaffolding models that we are implementing, and the questions and challenges that we have encountered in our implementation.

[1] APS-AAPT Joint Task Force On Undergraduate Physics Programs, “Phys21: Preparing Physics Students for 21st Century Careers,” (2016)

### GG03: 1:40-1:50 p.m. Early and Often – Threading Computation through the Physics Curriculum

*Contributed – Michele McColgan, Siena College, 13 Bacon Lane, Loudonville, NY 12211; mmccolgan@siena.edu*

Computational skills are highly desired for newly graduating physics majors pursuing graduate school or searching for their first job. At our small liberal arts college, very few freshmen physics majors come to us with programming experience. To overcome their fear and anxiety and avoidance of programming, we introduce programming concepts in their first semester and integrate it throughout most, if not all, of our courses. Research experience is strongly encouraged and financially supported beginning the summer after freshman year and continuing each summer. Along with independent studies and a senior project, it's difficult for our students to obtain a degree without significant exposure and experience with computation. In this talk I will describe how we thread computation through our physics curriculum.

### GG04: 1:50-2:00 p.m. “Computational Physics” vs. “Physics with Computation”

*Contributed – Larry P. Engelhardt, Francis Marion University, P.O. Box 100547, Florence, SC 29501 lengelhardt@fmarion.edu*

In our department, we have had a concentration in “Computational Physics” for about 20 years, but we have been increasing “integrating” computation into our “traditional” courses for the last 10 years. I will describe our progression towards increased computational integration and where we currently stand.

### GG05: 2:00-2:10 p.m. Making Computation Normal

*Contributed – Andrew D. Gavrin, Department of Physics, IUPUI, 402 N. Blackford St, LD154, Indianapolis, IN 46202; agavrin@iupui.edu*

In the physics department at IUPUI, we have embarked on a project to “make computation normal.” That is, we intend that by the time our students earn their BS, they will consider computation as a normal approach to problem solving, on par with an analytical approach. To do this, we are incorporating computational assignments and projects in all courses. Although we will use excel in the introductory course sequence, all upper level courses will rely on MATLAB, and we are introducing a two credit-hour sophomore level course to introduce students to this platform. We are also benefitting greatly from PICUP, the Partnership for Integration of Computation into Undergraduate Physics.\*

\*<https://www.compadre.org/PICUP/>

### GG06: 2:10-2:20 p.m. Integrating Computation into Introductory Physics: Interactive Modules for Beginner Programmers\*

*Contributed – Richelle M. Teeling-Smith, The University of Mount Union, 1972 Clark Ave., Alliance, OH 44601; teelinri@mountunion.edu*  
*Chris Orban, Chris Porter, The Ohio State University*

While there is a growing need to integrate computation into the physics curriculum, incorporating new content into an already jam-packed introductory physics course is a delicate task that involves many choices that may have a big impact on student learning. We introduce a series of hour-long programming activities for classical mechanics and electricity and magnetism. These interactive modules resemble popular games such as “asteroids” and “angry birds.” The activities are browser-based (requiring no software installation) and modular in nature so that they can be easily integrated into existing courses. We will discuss our experiences in integrating these programming exercises into the introductory physics courses at Mount Union and OSU Marion, as well as in high school physics classes in Ohio. We will discuss our progress on assessing learning gains quantitatively using an animated version of the FCI developed by M. Dancy, as well as a series of other animated questions.

\*The STEMcoding Project is supported by the AIP Meggers Award and internal funding from OSU.

### GG07: 2:20-2:30 p.m. Computational Exercises in Experimental Physics

*Contributed – Corey Gerving, United States Military Academy, Bartlett Hall Science Center, West Point, NY 10996; corey.gerving@usma.edu*  
*David O. Kashinski, United States Military Academy*

A challenge for many undergraduate physics students is how to deal with an equation of motion that has no exact solution, while experienced physicists are able to rely upon several numerical techniques. We introduce several numerical techniques into our senior-level experimental physics class for students to feel more com-

portable solving problems with no analytical solution. We focus our techniques primarily on the nonlinear pendulum or the damped harmonic oscillator as a means of expanding beyond the simplified models with analytical solutions. Here we discuss our learning objectives, our project requirements, and our results.

**GG08: 2:30-2:40 p.m. Bringing LaTeX into Introductory Calculus-based Physics for Homework and Computation**

*Contributed – Paul J. Heafner, Catawba Valley Community College, 3990 Herman Sipe Road, Conover, NC 28613-8907; heafnerj@gmail.com*

In this talk, I will describe how I introduced LaTeX into an introductory calculus-based physics course taught with Matter & Interactions and its associated computational tools. I submit that LaTeX can serve as a unique way to introduce computation with an immediately useful product for students, namely a professionally typeset and neatly organized homework paper with consistent notation, correct use of SI units, structured problem solutions with all work shown and with accompanying commentary, and inclusion of VPython or GlowScript programs (and live links to the latter). I will also describe *mandi*, a custom LaTeX package I wrote that facilitates all of this functionality.

**GG09: 2:40-2:50 p.m. Using Computation to Help Visualize Wave Functions in a Modern Physics Course**

*Contributed – Timothy A. Duman, University of Indianapolis, 1400 Hanna Ave., Dept. of Physics and Earth-Space Science, Indianapolis, IN 46227-3697; tduman@uindy.edu*

In recent years we have seen students in our modern physics course having difficulty representing wave functions for specified potential wells. This talk will present computational solutions to the time independent Schrodinger equation using jupyter notebooks (Python) to help students visualize and understand wave functions. The students are exposed to solutions for a variety of different potential wells. The shooting algorithm is used to solve the Schrodinger equation. Students are presented with a graphical representation of the wave function and asked to determine if it is a solution. They can click on the graph to select a different energy and produce a new wave function.

**Session GH: Models-based Physics Education – A Wendell Potter Memorial**

**Location:** Marriott Marquis - Silver Linden **Sponsor:** Committee on Physics in Undergraduate Education **Co-Sponsor:** Committee on Research in Physics Education  
**Time:** 1–3 p.m. **Date:** Wednesday, August 1 **President:** Eric Brewé

**GH01: 1:00-1:30 p.m. Models as Reasoning Tools: Wendell's Legacy**

*Invited – David J. Webb, Department of Physics, Univ. of California - Davis, Davis, CA 95616; webb@physics.ucdavis.edu*

In science and science education an understanding of the use and role of models as intellectual tools has become increasingly visible in recent years. The CLASP introductory physics courses developed by Wendell Potter and his colleagues at UC Davis explicitly invited students to learn the major 'models' that physicists used in thinking about the physical world. Wendell's emphasis was clear in i) the titles of the course books "College Physics: A MODELS Approach", ii) the naming of about two dozen specific models of physical phenomena, and iii) for each model, a summary that collected the verbal, mathematical, graphical, and pictorial tools to be used. In this talk I will try to outline Wendell's thinking and my own about the usefulness of this type of approach in science education as well as its connections to the work of practicing scientists.

**GH02: 1:30-2:00 p.m. Making Time for Sense Making: Designing Potter's Discussion-labs into Biology**

*Invited – Julia Gouvea, \* Tufts University, Department of Education, Medford, MA 02155; julia.gouvea@tufts.edu*

At the core of Wendell Potter's models-based approach to physics is a commitment to supporting students in making sense of the physical world. Potter's course design features five hours per week of "discussion-lab," creating the time and space for student-driven sense making. The students in this physics course are primarily biology majors, yet their biology courses tend to look nothing like discussion-labs. For the past four years I have been working to re-design introductory biology labs at Tufts University with the aim of supporting scientific sense making. In this talk I will describe how Potter's vision inspired the design of "hybrid labs" for introductory biology. In these labs, students conduct extended investigations that integrate experimental design and computational modeling. The labs also feature many opportunities for small-group and whole-class discussions. I will discuss the design features of hybrid labs that align with and extend Potter's curricular and pedagogical vision.

\*Sponsored by David Webb

**GH03: 2:00-2:30 p.m. (Still) A Radical Introductory Physics Curriculum: UC Davis CLASP**

*Invited – Charles J. De Leone, California State University, San Marcos, 333 S. Twin Oaks Valley Rd., San Marcos, CA 92096-0001 cdeleone@csusm.edu*

In 1997 Wendell Potter published a paper on the UC Davis CLASP curriculum titled "Radically Restructured Introductory Physics Course at a Large Research University." Over 20 years later, the CLASP curriculum has affected tens of thousands of students and remains "radical" in both the number and quality of the research-based elements the course employs. In this talk we will explore some of the varied elements of the CLASP curriculum from its use and training of teaching assistants, to its approach to curriculum. The talk will also explore how the CLASP curriculum views physical models and the modeling approach to instruction. This includes a discussion of the language difficulties in discussing physics problem-solving in a models-based approach.

**GH04: 2:30-3:00 p.m. Impact of Student-Centered Assessment Techniques on Student Success in CLASP**

*Invited – Cassandra Paul, San Jose State University, Department of Physics & Astronomy, One Washington Square, San Jose, CA 95192; cassandra.paul@sjsu.edu*  
*David Webb, Mary Chessey, UC Davis*

Wendell Potter and a team of dedicated educators created and first implemented the Collaborative Learning through Active Sense-making in Physics (CLASP) curriculum almost 25 years ago. Previously referred to as simply "Physics 7," the CLASP curriculum is an introductory physics course for non-majors, organized around several models that are considered foundational to physics. While the description of the course has always emphasized the importance of these models, the CLASP curriculum also boasts several other inventive instructional and assessment-related techniques each intended to provide a truly student-centered experience. Wendell emphatically and passionately advocated for some of these techniques throughout his career as an educator, and we are still today uncovering evidence of the wisdom behind his insight. In this talk, I describe some of the lesser-known practices used in CLASP, and share some evidence of their success at UC Davis, and at San Jose State University, a secondary implementation site.

## Session GI: Physics Beyond the Core

Location: Congressional Ballroom A Sponsor: Committee on Physics in Undergraduate Education

Time: 1–3 p.m.

Date: Wednesday, August 1

President: Juan Burciaga

### GI01: 1:00-1:30 p.m. The Capstone Experience for Physics Majors – Learning to Communicate Physics Beyond the Core

Invited – William J. Briscoe, The George Washington University, 725 21st Street, NW, Washington, DC 20052; briscoe@gwu.edu

A common observation of physics faculty in higher education is that undergraduate students lack STEM specific writing skills. Students have difficulties with the specific genres of physics writing such as research articles, abstracts, technical reports, review articles, and proposals. These common types of scientific writing are each governed by different conventions of grammar, format, and style, and they each serve a particular rhetorical purpose targeted for a particular audience. Additionally, students struggle to incorporate sources such as journal articles, conference proceedings, chapters, plots and graphs, or tables correctly and effectively into their writing. A collaboration between the Physics Department and the University Writing Program studies whether explicit teaching of two transfer-focused writing skills – genre awareness and source application – enhances student writing across a sequenced, upper division, undergraduate capstone course for physics majors.

### GI02: 1:30-2:00 p.m. Teaching Condensed Matter Physics at Johns Hopkins

Invited – Oleg Tchernyshyov Department of Physics and Astronomy Johns Hopkins University 3400 N. Charles St. Baltimore, MD 21218 olegt@jhu.edu

Undergraduates at Johns Hopkins have an opportunity to take physics courses beyond the core requirements. At least 2 of these are required for a B.A. degree in Physics; at least 5 for B.S. Examples of such courses are Introduction to Stellar Physics, Condensed Matter Physics, Nuclear and Particle Physics, and Physical Cosmology. In addition, our physics majors can take graduate-level courses such as Stellar Structure, General Relativity, Advanced Condensed Matter, Phase Transitions and Critical Phenomena, and Quantum Field Theory. I will share my experience teaching condensed matter physics to undergraduates.

### GI03: 2:00-3:00 p.m. Computationally Concretizing Thermal Physics for IPLS -- From Spatial to Energy Spreading

Poster – Ariel Abrashkin, Weizmann Institute of Science, 6 sderot hatzionut, Tel Aviv, Israel 62157 Israel arielab2002@gmail.com

Ariel Steiner, Samuel Safran, Edit Yerushalmi, Weizmann Institute of Science

Biological cells consist of molecules in aqueous solution, serving as a thermal reservoir. The analysis of such systems relies on the laws of thermodynamics, and the conceptualization of energy and its associated entropy. We suggest an instructional sequence in which thermal contact is presented in terms of energy diffusion in the system, in analogy to a more concrete context – particle diffusion involving spatial entropy and the second law. Working in a framework of non-interacting particles, having only kinetic energies, enables a simple and concise definition of temperature and thermal equilibration. To illustrate our approach, we demonstrate a simulation-based discovery activity in which students investigate thermal contact between particles occupying the same volume, relevant to biomolecules in solution. Next, potential energy arising from interparticle interactions, crucial for structure formation (e.g. membranes, vesicles), is introduced. In this context, we derive the Boltzmann factor accounting for interactions from the first and second laws.

### GI04: 2:00 PM-03:00 PM Computationally Concretizing Thermal Physics for IPLS – Paving the Way

Poster – Haim Edri, Weizmann Institute of Science, 234 Herzl St., Rehovot, 7610001 Israel haim.edri@weizmann.ac.il

Samuel Safran, Edit Yerushalmi, Weizmann Institute of Science

Central position papers present a challenging task -- the inclusion of thermal physics as part of the IPLS course. We present the first unit in an introductory science curriculum that uses computational tools to explain the random nature of multi-particle-systems, crucial in statistical physics, while taking into account students' limited prior knowledge. The unit focuses on diffusion – an important generic characteristic of ions in solution and many other biomolecules, engaging students in constructing a series of computational models intended to align the stochastic nature of random walks with their prior knowledge of Newtonian mechanics. Students analyze the development of particles' trajectories in time at different time scales. This analysis serves to justify the shift from deterministic model of the motion of one or two particles in vacuum, to a model of colloidal particle dominated by frictional and stochastic forces, resulting from the interactions with the many-particles of the solvent.

### GI05: 2:00-3:00 p.m. Computationally Concretizing Thermal Physics for IPLS: Goals, Dilemmas, Choices

Poster – Edit Menuha Yerushalmi, Weizmann Institute of Science, 10 Haim Haviv St., Jerusalem, 96788 Israel edit.yerushalmi@weizmann.ac.il

Ariel Abrashkin, Haim Edri, Elon Langbeheim, Ariel Steiner, Sam Safran, Weizmann Institute of Science

The physics of mesoscale structure formation — how do many molecules organize themselves into large-scale assemblies — is at the heart of biological physics. We present the dilemmas and choices underlying an introductory curriculum that gradually builds the knowledge structure required to address this question. The research-based-curriculum was tested in a course for interested and capable high-school students, and refined over three implementation cycles, introducing several shifts from traditional curricula to meet students' limited prior knowledge: Dynamics presented with a focus on motion dominated by frictional and stochastic forces. The step-by-step evolution of many-particle-systems, dominated by spatial randomness, towards equilibrium, is analyzed and pictured by means of computational models. Introductory level equilibrium statistical thermodynamics is presented in the context of particle diffusion involving spatial entropy; as a precursor to analogous treatment of thermal contact. Finally, Monte-Carlo simulations serve to concretize analytical models of structure formation in systems where interactions compete with randomness.

### GI06: 2:00-3:00 p.m. Computationally Concretizing Thermal-Physics for IPLS – From Dynamics to Equilibrium Statistics

Poster – Ariel Steiner, Weizmann Institute of Science, Harikma 45/3 St., Givaat Yearim, Israel 9097000 ariel.steiner@weizmann.ac.il

Ariel Abrashkin, Sam Safran, Edit Yerushalmi, Weizmann Institute of Science

Computational dynamical models were used in the first unit of an introductory science curriculum to concretize the shift from Newtonian dynamics to particle diffusion modeled as a random-walk. In the second unit of the course this is followed by the abstract statistical-thermodynamics treatment of non-interacting systems assuming equal probability of all microstates (spatial configurations). This unit demonstrates the superfluous nature of the random-walk model for diffusion, accounting for the time-evolution of all particle trajectories, when used to describe equilibrium. Students compare the long-time averaged density distributions of random-walk vs. Monte-Carlo simulations anchored in the equal probability assumption and realize that both lead to constant density. Students justify the assumption by examining spatial sampling in a random-walk model for the relevant measurement timescales. This analysis sets the stage for later discussions of entropy and the second law as-well-as analysis of other systems relevant to life sciences, such as polymeric macromolecules.



**GI07: 2:00-3:00 p.m. Space Weather Awareness Helps Engage and Retain Students in Science**

Poster – Anna Chulaki, CCMC NASA GSFC, 7 Fayette Place, Greenbelt, MD 20770-1602; [anna.chulaki@nasa.gov](mailto:anna.chulaki@nasa.gov)

Yaireska Collado Vega, CCMC NASA GSFC

Recent advances in the young field of space weather allow scientists to paint a picture of the daily life of the Sun and its influence on our electromagnetic environment. Using physics-based models we predict the propagation of solar storms through the solar system and their arrival at Earth, other planets and satellite missions. CCMC provides college undergraduates with an extraordinary learning experience of planetary dimensions and immense visual beauty by engaging them in space weather forecasting and forefront research via cutting edge models and tools. Young forecasters gain awareness of our wider environment, an understanding of the fundamentals of the Sun-Earth system and knowledge of the impacts of space weather on humans and technological systems. We would love to share our experience and resources and partner with teaching institutions to promote space weather awareness to younger audiences as a means to recruit and retain young people in science.

**GI08: 2:00-3:00 p.m. Educational Issues Details Pertaining to Claims about Anthropogenic Climate Change**

Poster – Laurence I. Gould, University of Hartford, Physics Dept., 200 Bloomfield Ave., West Hartford, CT 06117-0395; [lgould@hartford.edu](mailto:lgould@hartford.edu)

Many arguments have been made that — as a result of human activities that emit greenhouse gases (mainly carbon dioxide) — there is a dangerous trend of increasing global temperatures resulting in events such as melting glaciers, rising sea levels, and increased storms. This talk draws on topics from a one-semester freshman seminar course taught at the University of Hartford in 2009, 2014, and 2017. The course was devoted to a critical-thinking approach to the topic of Anthropogenic Climate Change. The presentation will — through an analysis that includes some of those arguments and methodologies — show how curious people can seek a deeper understanding of the issues and thus enhance their ability at scientific enquiry. The material should be of particular interest to students and educators.

Gould, L.I. "Systematic And Logical Problems In Global Warming Science" ENERGY & ENVIRONMENT Volume 25 - No. 6 & 7, 1205 - 1219 (2014)

**GI09: 2:00-3:00 p.m. Engineering Physics Field Session at Mines: Incorporating Open-Ended Problem Solving**

Poster – Chuck Stone, Colorado School of Mines, 1523 Illinois St., Golden, CO 80401; [cstone@mines.edu](mailto:cstone@mines.edu)

Vince Kuo, Colorado School of Mines

Following their sophomore year of studies, physics majors at Colorado School of Mines enroll in a 6-week, 6 credit hour summer course, Field Session Techniques in Physics. The course introduces students to the design and fabrication of engineering physics apparatus and involves intensive individual participation in the design of machined system components, vacuum systems, electronics, optics, and applications of computer interfacing systems and computational tools. It includes supplementary lectures on safety, laboratory techniques, and professional development, along with visits to regional research facilities and industrial plants. This poster presentation will describe how the Mines Physics Department has incorporated open-ended problem solving in Field Session Learning Modules and nurtured student independence and creativity in problem-solving processes.

**GI10: 2:00-3:00 p.m. Preparing Students for Long-Term Open Inquiry Projects -- Students' Perspective**

Poster – David Perl, \*Weizmann Institute of Science, 27 weizmann St., Rehovot, Rehovot 7628207 Israel [davidperl6@gmail.com](mailto:davidperl6@gmail.com)

Edit Yerushalmi, Weizmann institute of science

The advanced high school physics course is commonly directed towards a high stake exam. A three-year course, titled INQUIRY-PHYSICS, takes place in Israeli education system as an addition to the traditional physics course. It intends to bypass the difficulty of integrating open ended inquiry activities into test oriented setting. This timeframe allows for a gradual learning progression, developing inquiry practices in contexts that span from 1-2 lessons to a yearlong research project. I will describe the findings of an artifact-based interview that took place few months after the students launched their work on the research project. Student were asked to identify inquiry practices they have encountered earlier in the course and reflect on their fruitfulness. In particular, which of these practices they perceive as crucial to experience before engaging in a long term project. I will discuss these findings in view of the learning goals and design principles of the teachers.

\*Sponsored by Edit Yerushalmi

**GI11: 2:00-3:00 p.m. Using the NSF S-STEM Grant to Improve STEM Student Success**

Poster – Tom Carter, College of DuPage, 425 Fawell, 425 Fawell Blvd., Glen Ellyn, IL 60137; [cartert@cod.edu](mailto:cartert@cod.edu)

Barbara Abromitis, Susan Fenwick, Tom Schrader, Richard Jarman, College of DuPage

The College of DuPage, a large two-year college in suburban Chicago, secured a grant from the National Science Foundation's S-STEM program in 2016. The allowed COD to award full scholarships to up to 60 students majoring in chemistry, physics, or engineering over five years. Along with the scholarship, a key goal of the program was to provide the students academic support to aid them in completing a two-year program for graduation or transferring to a four-year institution. A central feature of the project is the use of a STEM Student Success Coach who will provide individual, cohort, program-specific, and interdisciplinary guidance as a cost-effective way of addressing attrition in STEM disciplines at the community college level. Quantitative/qualitative data will inform program decisions, resulting in a replicable model, disseminated through a variety of professional outlets. A second feature of the proposal is the use of research internships that will leverage existing partnerships with four-year institutions and national laboratories.

**GI12: 2:00-3:00 p.m. The Principia's Second Law of Motion, and Euler's  $F=ma$**

Poster – Ajay Kumar Sharma, Fundamental PHYSICS Society, His Mercy Enclave Post Box 107 GPO, shimla, HP 171001 India [ajoy.plus@gmail.com](mailto:ajoy.plus@gmail.com)

Newton had given Second Law Of Motion in the Principia (1687) at page 19 as "The alteration of motion is ever proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed." Newton did not give any equation for the law as it was not tradition at that time. While explaining law after definition Newton did not write word acceleration (rate of change of velocity) as it was not imagined at that time ( not in known and unknown quantities) . Newton defined 'quantity of motion'  $mv$  at page 2 and expressed motion as velocity at page 9. Thus mathematical form of second law turns out to be  $F = m(v-u)$  or  $F = (v-u)$ .  $F=ma$  was given by Euler and can be seen at Index no E479 at page 223 at website of MAA where Euler's original works are archived.

**GI13: 2:00-3:00 p.m. No One Became a Physics Major to Research Blocks on an Inclined Plane**

Poster – Richard Gelderman, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101-1077; [gelderman@wku.edu](mailto:gelderman@wku.edu)

Robin became a physics major to work on teleportation. Chris wants to study cosmology (though his inability to pass calculus 2 might limit him to cosmetology).

So why do we keep them bogged down with the cartoon physics of the 18th or 19th century? The Western Kentucky University physics program now starts with Introductory Modern Physics, where atoms, quantum effects, and relativity are introduced without calculus. Juniors and seniors complete their required electives with fully developed lab courses dealing with astrophysics, materials science, nuclear, and/or multidisciplinary science for this millennium's Homeland Security.

**GI14: 2:00-3:00 p.m. Why Sir Isaac Newton was Sitting Under the Apple Tree...**

Poster – Mikhail M. Agrest, *The Citadel*, 87 Droos Way, Charleston, SC 29414; MAgrest@Citadel.edu

When Sir Isaac Newton was sitting under the apple tree thinking about the Universe an apple fell on his head and he invented the first Newton's law... Was it Newton's acceptance of Rene Descartes' "Cogito ergo sum"? Why in the world Sir Isaac Newton was still sitting under the apple tree thinking about the Universe instead of doing something useful to feed his family. Wasn't Newton himself giving credit for his first law to Galileo for seeing that the zero net force leads to rest, or uniform motion? It is essential that in teaching physics we bring to the students' attention that Newton's approach brought physics to the level of understanding of similarity of events that look very different and differences of events looking very much similar. Sir Isaac Newton didn't "invent calculus to solve mathematical problems," but to make concepts of physics be visible through similarity and differences.

**GI15: 2:00-3:00 p.m. Computationally Concretizing Thermal Physics for IPLS – From Energy to Complexity**

Poster – Elon Langbeheim, *Weizmann Institute of Science*, 234 Herzl St., Rehovot, Israel 7610001 elon.langbeheim@weizmann.ac.il

Samuel Safran, *Edit Yerushalmi*, *Weizmann Institute of Science*

Structural complexity is quintessential to biological systems that contain many interacting molecules (e.g., cell membranes, cytoskeleton). The derivation of analytical models that explain structure formation in biological systems requires mathematical treatments of entropy and internal energy which may be beyond the reach of introductory students. Monte-Carlo computational models are an alternative path for the analysis of such biological systems. A lattice-based Monte Carlo simulation samples the configurations of the system by starting from an arbitrary configuration, and then alters the location or orientation of each component (e.g., lipid molecule) using random steps. Each step can then change the potential energy of interaction through the variation of the separation of a given component and its neighbors. The Boltzmann factor is used to calculate the acceptance probability of each step, based on the change in potential energy. We will demonstrate how students use this method for modeling processes in complex biological systems.

**Session GJ: Physics for Refugees & Distant Education**

**Location:** Meeting Room 2 **Sponsor:** Committee on International Physics Education **Co-Sponsor:** Committee on Educational Technologies **Time:** 1–2:30 p.m.

**Date:** Wednesday, August 1 **President:** André Bresges

**GJ01: 1:00-1:30 p.m. Constituting Effective Learning Environments for Non-traditional Students**

Invited – Cedric Linder, *Institutionen för fysik och astronomi, Avdelning för fysikens didaktik, The Ångström Laboratory, Uppsala Universitet, Lägerhyddsvägen 1 Uppsala, 751 20 Sweden* cedric.linder@physics.uu.se

Johan Larsson, *Uppsala University*

The constitution of effective learning environments in introductory physics takes on special significance when the participating students have a traumatic and/or deprived socio-economic background. In this presentation reflections on two such learning environments will be presented, one situated in South Africa and the other in Sweden. In so doing, Alfred Whitehead's notion of educational rhythm and Paul Hewitt's advocated communicative practice (use of semiotic resources) will be used to frame story-lines of accomplishment and on-going challenge.

**GJ02: 1:30-2:00 p.m. Physics for Refugees in Cologne: Introduction and the Refugee Center**

Invited – Florian Genz, *ZuS - Universität zu Köln, WeilburgerStr.2, Köln, 51105; Germany* fgenz1@uni-koeln.de

Sara Lotfipour, Dan L. Maclsaac, Kathleen A. Falconer, *Universität zu Köln*

We start with an introduction to the German Physical Society's (DPG) physics for refugees program Physik für Flüchtlinge (Pff), including history, motivation, prevalence and formal materials from their website. Next we briefly describe the transition refugee center administered by the Red Cross and the refugee children there who participated in weekly Pff afternoon classes. Then we will present and describe the Pff activities we have carried out to date at the center at length and with commentary.

**GJ03: 2:00-2:30 p.m. Physics for Refugees 2: Grade School and Lessons Learned**

Invited – Daniel Maclsaac, *SUNY Buffalo State College Physics, SAMC278, 1300 Elmwood Ave., Buffalo, NY 14222; macisadl@buffalostate.edu*

Michael Resvoll, *Stadt Gymnasium Köln Thusneldastraße*

Florian Genz, Kathleen A. Falconer, *Universität zu Köln*

We start with an overview of the (Junior and Senior High School) Stadt Gymnasium Köln at Thusneldastraße physics class dedicated to Physics for Refugees (Pff), including history, motivation, and a description of the school, teachers, non-refugee student assistants (Helferin\*innen) and a lengthier description of the Thesneldastraße refugee students. We will include details about the support materials and efforts provided to refugees, particularly to those support materials and concepts focusing on language and interrupted learning. Further, we present and describe Pff activities carried out to date at the Gymnasium. A lengthy discussion of lessons learned including focus, strategies, and advice to others working with refugee children learning physics will end the presentation.

## Session GK: Panel – Physics Laboratories in the NSF IUSE Program

**Location:** Meeting Room 3    **Sponsor:** Committee on Laboratories    **Co-Sponsor:** Committee on Research in Physics Education    **Time:** 1–3 p.m.  
**Date:** Wednesday, August 1    **Presider:** Robin Wright

*This two-hour panel session will begin by each panelist delivering a 15-minute overview presentation on the work of their NSF IUSE award. The presider will then lead a panel discussion of issues surrounding undergraduate physics laboratories at all levels, allowing questions from the audience. The panel discussion is anticipated to probe recommended instructional practices, the skills and conceptual knowledge we wish to impart to students, appropriately assessing these skills and knowledge, and dealing with the constraints and taking advantage of the affordances of laboratory settings and formats.*

### Speakers:

*Sean M. O'Malley, Rutgers University,*

*Brian R. D'Urso, Montana State University,*

*Natasha G. Holmes, Cornell University,*

*Heather J. Lewandowski, the University of Colorado - Boulder.*

## Session GL: Physics Majors: Middle School to Doctorate

**Location:** Meeting Room 4    **Sponsor:** AAPT    **Time:** 1–2:30 p.m.    **Date:** Wednesday, August 1    **Presider:** Genrikh Golin

### GL01: 1:00-1:10 p.m. Finding My Balance

*Contributed – Kathleen L. Willard, Monessen City School District, 1245 State Road, Monessen, PA 15062; kwillard@wiu.k12.pa.us*

For the first time in 15 years, my school district required me to teach 7th grade science. There were many challenges and frustrations along the way. I had to re-evaluate what were reasonable expectations. Many of the things that I expect students to know by the time I have them in class were now the things that I needed to teach them.

### GL02: 1:10-1:20 p.m. Introduction of Observer Dependent Concepts into Middle School Physics Teaching

*Contributed – Ben Stein,\* The Hebrew University of Jerusalem, Israel, 37B Hashomron St., Rishon Lezion, Israel 7547325 Israel checkmath@gmail.com*

*Igal Galili, The Hebrew University of Jerusalem, Israel*

Physics curricula of middle school and high school avoid dealing with the concept of observer (frame of reference). This tradition apparently draws on the assumption that school students are incapable of learning observer dependent concepts since they require multiple values valid for different observers. We empirically checked this convention. Our experimental teaching comprised 15 meetings with 9th grade students and addressed concepts from kinematics and dynamics. We examined students' success in elaborating chosen concepts in different frames of references in context of regular physics teaching. We found that 9th grade students succeeded in applying frame of reference dependence in their graphical accounts of displacement, distance, and velocity as time dependent for different observers. Operationally defined force allowed introduction of inertial forces and non-gravitational weight valid for non-inertial observers. We argue that teaching observer dependence of concepts is a powerful tool for achieving mature and genuine knowledge of classical mechanics.

\*Sponsored by Igal Galili

### GL03: 1:20-1:30 p.m. Effectiveness of PBL in the Academic Performance of Physics Students

*Contributed – Fatih Ilhan, Harmony School of Nature, 6855 Clarkwood Dr., Apt 402, Dallas, TX 75236; filhan@harmonytexas.org*

Harmony Public Schools have built up a STEM educational modules that fuse project-based and request based learning titled STEMSOS "STEM Students on the Stage (SOS)". Students practice PBL project at different levels at Harmony Public Schools. Level I is a classroom implemented and targets 21st-century aptitudes inside the setting of the educational modules. Level II and Level III are long-term interdisciplinary project associating STEM educational modules to the humanities through rich, significant, and thorough cross-disciplinary and multi-tactile project that permit the application and improvement of basic 21st-century abilities. I will demonstrate a few cases of PBL Level II sites and video that were made by my students last school year. You may see some examples on the tables.

### GL04: 1:30-1:40 p.m. AP Physics in a Chinese School

*Contributed – Igor V. Proleiko, Tianyi AP Center, 18 Er Quan Middle Road, Wuxi, Jiangsu 214000 China igor.proleiko@yandex.ru*

Chinese students taking AP classes in Chinese schools are famous for a high degree of academic rigour and exceptional mathematical background. However, certain practices in Chinese education require adjustment in AP Physics classes, especially when experimental work and open end questions are concerned. I will share the experience of overcoming these obstacles with the Chinese student and preparing them for pursuing their education in Western cultural and academic environment.

### GL05: 1:40-1:50 p.m. Learning Assistant Program Impact for Non-Traditional Transfer Physics Majors

*Contributed – Patrick L. Chestnut, 201 Mullica Hill Road, Glassboro, NJ 08028-1700; chestnut@rowan.edu*

Rowan University, a public school located in southern New Jersey, serves a high number of non-traditional transfer students. Almost half of all upper-division students within the Department of Physics and Astronomy are transfer students, and one-tenth are over age 24. This population often faces unique challenges compared to traditional students matriculating directly from high school. Our team will present findings from interview data with transfer students who serve the department in the role of learning assistants within introductory physics courses. Analysis of interview data provides insights into challenges and opportunities this population faces and manners to which the LA program has been beneficial to student development.

**GL06: 1:50-2:00 p.m. Understanding the Choice of Studying Physics in Higher Education**

Contributed – Kelvin Au,\* University of Manitoba, Faculty of Education, Winnipeg, MB R3T 2N2 Canada auk@myumanitoba.ca

Richard P. Hechter, University of Manitoba

An investigation into why physics is an uncommonly chosen field of study is explored. Many individuals find physics to be a fascinating subject and demonstrate some capacity of interest in physics-related content matter, but do not choose it as a focus of study in and beyond undergraduate education. Variables that may contribute toward decisions of whether or not to pursue studies in physics include: 1) interests; 2) attitudes; and 3) beliefs. An analysis into the possible connections between these three variables is performed, and further analysis into each variable is conducted to understand how interests, attitudes, and beliefs toward and surrounding physics might have originated.

\*Sponsored by Richard P. Hechter

**GL07: 2:00-2:10 p.m. Engaging Undergraduates in Original Research in Their First College Course: Logistics and Impact**

Contributed – Kristine Lang, Colorado College, 14 E. Cache la Poudre, Colorado Springs, CO 80903; kmlang@coloradocollege.edu

Undergraduate research is an integral part of science education; however, many students begin college with no clear idea what research is or how to get involved. In this talk I describe a First-Year Experience course in which students work on an original research project that is part of an ongoing physics-biology interdisciplinary research program. During the course, students participate in every aspect of research from reading background journal articles and designing the experiment, through data collection and analysis, and they finish by using their own original data to write a scientific journal article. Here I describe the “nuts and bolts” of the course structure. In addition, I present an assessment of the course impact on students. The data shows that students in this course engage in subsequent research at a much higher rate and for more total time than students who took similar science-oriented FYE courses without a research component.

**GL08: 2:10-2:20 p.m. Concept Cartoons for Student Engagement and Critical Thinking\***

Contributed – Kausik S. Das, University of Maryland Eastern Shore, 1, Backbone Road, Princess Anne, MD 21853; kdas@umes.edu

This presentation discusses student engagement strategies in physics by: 1) encouraging students to interact with their peers through group learning, 2) using visualization and humor as an engagement tool through concept cartoons, and 3) integrating the concept cartoons to clicker questions for real-time, in-class feedback and assessment of learning outcomes. The goal is to creating a pool of concept cartoon-based clicker questions to enhance both engagement and critical thinking. We expect that implementation of these changes will significantly affect students’ learning outcomes, help them to excel, boost their confidence and achievement levels, and in turn, improve overall undergraduate STEM retention.

\*K.D. would like to thank Department of Education (grant # P120A70068) and National Science Foundation (grant # 1719425) for partial financial support.

**GL09: 2:20-2:30 p.m. Becoming Cultural Navigators in a Graduate Physics Community\***

Contributed – Deepa N. Chari, Florida International University, STEM Transformation Institute, Miami, FL 33199; deepu.chari@gmail.com

Geoff Potvin, STEM Transformation Institute and Department of Physics, Florida International University

Graduate students who enroll in APS Bridge Program have a unique experience in the first one to two years of graduate school, as they perceive themselves to be neither undergraduates nor “typical” graduate students during these bridging years. In this study, we aim to understand what institutional and individual practices are considered important by bridge students for the successful completion of bridging years. We applied a communities of practice framework and examined 14 Bridge students’ first year experiences. Particularly, we studied the development of a “course-takers” community to better understand the practices that support students’ transition through bridging years. We report on how graduate students not only develop this course-takers communities, but also become cultural navigators for subsequent cohorts in interacting with the broader graduate community in their departments.

\*This research is supported by the National Science Foundation Grant No. 1143070.

**Session GM: STEP UP 4 Women**

**Location:** Meeting Room 5    **Sponsor:** Committee on Women in Physics    **Co-Sponsor:** Committee on Physics in Two-Year Colleges    **Time:** 1–2:40 p.m.  
**Date:** Wednesday, August 1    **President:** Rebecca Vieyra

**GM01: 1:00-1:30 p.m. STEPUP 4 Women: A Radical Approach Changing Demographics of Physics\***

Invited – Theodore Hodapp, American Physical Society, One Physics Ellipse, College Park, MD 20740; hodapp@aps.org

Kathryne Woodle, American Physical Society

Rebecca Vieyra, American Association of Physics Teachers

Zahra Hazari, Florida International University

Robynne Lock, Texas A&M Commerce

20% — Despite significant advances in bringing women into physics over the past five decades, women still remain woefully underrepresented. Now, APS and AAPT are teaming up with top researchers in gender studies in physics to design a completely new approach to increasing the representation of women in physics. The key: enlisting 15,000 high school teachers to use evidence-based strategies in their classrooms to directly recruit women into the study of physics. This session will describe the approach and results from our pilot efforts this past academic year to reach teachers across the country. Bring your questions, and contacts to help us achieve this audacious goal.

\*This material is based upon work supported in part by the National Science Foundation under Grant No. (NSF-1720810).

**GM02: 1:30-1:40 p.m. STEP UP 4 Women: Promoting Widespread Implementation of the Initiative\***

Contributed – Raina M. Khatri, Florida International University 11200 SW 8th St Miami, FL 33199; raina.m.khatri@gmail.com

Kathryne Woodle, American Physical Society

Rebecca Vieyra, American Association of Physics Teachers

Zahra Hazari, Florida International University

This talk reports on work related to the STEP UP 4 Women project. The national STEP UP 4 Women initiative aims to mobilize high school physics teachers to

encourage women in their classes to consider majoring in physics. This initiative includes lesson plans and teaching strategies grounded in education and physics identity literature that, if implemented, can help students seriously consider a future for themselves in physics. However, reaching tens of thousands of teachers to implement new lessons represents a challenge; both experience and literature indicate that research-based instructional strategies often go unused by instructors, even if the lessons appear to be a good idea. In this talk, I will draw upon research in educational change and discuss the STEP UP team's propagation plan to encourage the widespread use of the potentially transformative materials.

\*This work is supported by the National Science Foundation under Grant No. 1720810, 1720869, 1720917, and 1721021.

**GM03: 1:40-1:50 p.m. STEP UP 4 Women: Developing Physicist Profiles for a Career Exploration Lesson\***

*Contributed – Michelle C. Layana, Florida International University, 11200 SW 8th St., Miami, FL 33199; mlaya001@fiu.edu*

*Nicole Cook, Ingelise Giles, Zahra Hazari, Geoff Potvin, FIU*

*Allan Teer, Texas A&M University Commerce*

This talk reports on work related to the STEP UP 4 Women project. In developing a career exploration lesson for this project, we created individual profiles illustrating a variety of potential careers that can be obtained with a bachelor's degree in physics. These profiles were based on prior research to showcase physics careers in ways that articulate the values of many individuals, particularly women. Having career stability, having a family-friendly work environment, and serving or helping others are some of the values that many women have been found to seek in choosing a career. Each profile was selected to be relatable to students while also being obtainable. This humanizes careers in physics and shows the spectrum of values that motivate physicists. This talk will discuss themes in the career profiles, why particular profiles were chosen, and how this development will support a broader conversation about physics careers in classrooms.

\*This work is supported by the National Science Foundation under Grant No. 1720810, 1720869, 1720917, and 1721021. Additional Co-authors: Authors: Michelle Layana (FIU) and Zahra Hazari (FIU)

**GM04: 1:50-2:00 p.m. STEP UP 4 Women: Analyzing Student Identity Development in Two Classroom Interventions\***

*Contributed – Hemeng Cheng, Florida International University, 11200 SW 8th St., Miami, FL 33199; hchen033@fiu.edu*

*Geoff Potvin, Michelle Layana, Zahra Hazari, Florida International University*

*T. Blake Head, Allan Teer, Robynne M. Lock, Texas A & M University Commerce*

As part of the STEP UP 4 Women project, two lessons were developed for high school physics classes focused on facilitating the physics identity development of female students. The first is a career exploration lesson that links students' values and goals to potential physics careers that matched these values and goals. The second is an underrepresentation discussion lesson which drew on evidence of gender issues in physics to elicit students' reflection on implicit bias and stereotypes and, by doing so, to begin pushing back against them. These lessons were implemented by 11 high school physics teachers in eight states across the U.S. Students completed pre-/post-surveys that probed both physics identity and future time perspective. This talk will report on the results of the pre-/post-data analysis for both lessons as well as the implications of these results for improving the lessons and their implementation.

\*This work is supported by the National Science Foundation under Grant No. 1720810, 1720869, 1720917, and 1721021.

**GM05: 2:00-2:10 p.m. Examining Students' Responses to a Career Exploration Lesson\***

*Contributed – Thomas Blake Head, Texas A&M University - Commerce, Department of Physics and Astronomy Commerce, TX 75429; thead2@leomail.tamuc.edu*

*Allan Teer, Robynne M. Lock, Texas A&M University - Commerce*

*Zahra Hazari, Florida International University*

This talk reports on work related to the STEP UP 4 Women project. Eleven high school physics teachers implemented two lessons developed as part of this project during the Fall 2017 semester. One lesson focused on physics careers, while the other lesson centered on a discussion of the underrepresentation of women in physics. In this talk, we will discuss how students' perceptions of physics are affected by the career exploration lesson through an analysis of student and teacher artifacts. Data collected include teacher reflections, student open-ended survey responses, and student work such as career profiles in which they envision themselves achieving their goals with a physics degree.

\*This work is supported by the National Science Foundation under Grant No. 1720810, 1720869, 1720917, and 1721021.

**GM06: 2:10-2:40 p.m. STEP UP 4 Women: Discussing the Implementation of Strategies with High School Physics Teachers\***

*Invited – Kristin Holz, Talkington School for Young Women Leaders, 415 North Ivory Ave., Lubbock, TX 79403; rvieyra@aapt.org*

*John Metzler, Niles West High School*

*Moses Rifkin, University Prep*

*Catherine Garland, Uncommon Charter High School*

The STEP UP 4 Women project includes a team of high school physics teachers who are helping to refine and test strategies for engaging more female students such that they begin to develop physics identities and consider pursuing bachelor's degrees in physics. As members of the master teacher team, we will discuss our implementation of the lessons and strategies in order to better understand how to enhance effective implementation amongst a wide variety of high school classes. All physics teachers are encouraged to attend to further the discussion of how we can, through our practices, positively affect a long-standing issue in physics. Together, physics teachers have the opportunity to drive a historic change in the representation of women in physics.

\*This work is supported by the National Science Foundation under Grant No. 1720810, 1720869, 1720917, and 1721021.

**Session GN: Teacher Training/Enhancement**

**Location:** Marriott Marquis - Magnolia

**Sponsor:** AAPT

**Time:** 1-2:20 p.m.

**Date:** Wednesday, August 1

**President:** Susan Engelhardt

**GN01: 1:00-1:10 p.m. How We Learned to Stop Worrying and Love RBISs**

*Contributed – Jon Gaffney, Hamilton College, 198 College Hill Rd., Clinton, NY 13323; jon.teaches.physics@gmail.com*

*Paul Hutchison, Grinnell College*

Research-based instructional strategies (RBISs) improve students' performance in physics classes. However, successfully implementing RBISs is often difficult to do. Sometimes, instructors struggle with concerns that they will not know what to do when something unexpected happens in the classroom, such as a student providing a bizarre answer or asking a question that seems to be only tangentially relevant to the conversation. We argue that RBISs require the creation of an appropriate environment, where student ideas ferment and evolve, to enact the desired deeper understanding. Further, we position instructor moves as mechanisms for creating and managing such an environment. We offer reassurance that even experienced instructors miss rich opportunities while managing this environment, and we provide an encouraging framework for anyone wanting to transition their teaching towards being more responsive and less prescriptive.

**GN02: 1:10-1:20 p.m. Truth, Success, and Faith: Teacher Perceptions of What Responsive Teaching Puts at Risk\***

*Contributed – Amy D. Robertson, Seattle Pacific University, 3307 Third Ave W, Suite 307, Seattle, WA 98119-1997; robertsona2@spu.edu*

*Leslie J. Atkins Elliott, Boise State University*

Responsive teaching – or teaching in which instructors attend to and build on student ideas – is depicted by the literature as both important and challenging. It is important in that this kind of teaching not only supports the development of students' conceptual understandings but also invites students to engage in the refinement of their own ideas, in ways that embody how professional science is done. It is challenging in that it is a departure from traditional instruction; for example, classrooms in which students are invited to pursue their own thinking can seem messy or disorganized to institutional stakeholders. This talk will explore additional facets of what is challenging about responsive teaching. That is, according to teachers from our local teacher education and professional development contexts, responsive teaching puts truth, student success, and student faith at risk, creating a moral – not strictly institutional – dilemma for teachers as they consider teaching responsively. We will give example quotes from teacher reflections to illustrate what they see as at risk, and we will briefly explore implications for teacher education.

\*This material is based upon work supported by National Science Foundation Grant No. 1418211.

**GN03: 1:20-1:30 p.m. #iteachphysics Twitter Chats and Community of Practice Website**

*Contributed – Lawrence Norris, 6704 Lee Highway Unit G, Arlington, VA 22205-1962; lnorris@lnorris.org*

Bi-weekly #iteachphysics Twitter chats started in September 2014 and have grown to be a valuable resource for scores of physics teachers worldwide. Each hour-long chat centers around a specific topic, which over the years has included teacher leadership, teaching about magnets and magnetism, robotic telescopes, Physics First, the Pulsar Search Collaboratory, teaching optics, modern physics, quantum mechanics, vector calculus with virtual reality, metacognition in problem solving and more. The chats will soon be augmented with an online professional community of practice, iteachphysics.org, where participants can share resources more extensively, make blog and discussion group postings, and social network. In this talk, this activity will be detailed and put in the context of best practices for teacher professional development.

**GN04: 1:30-1:40 p.m. Developing an Energy Unit Integrating Engineering Design in Science Classrooms**

*Contributed – Yuri B. Piedrahita, Purdue University, 100 N. University St., West Lafayette, IN 47906; ypiedrah@purdue.edu*

*Chandan Dasgupta, Indian Institute of Technology*

*Alejandra J. Magana, N. Sanjay Rebello, Purdue University*

Next Generation Science Standards (NGSS Lead States, 2013) call for integrating processes of Engineering Design in K-12 science instruction, and the current issues related to energy saving, encouraged us to design an instructional unit that integrates the learning of thermal energy transfer with engineering design. The design was implemented in a physics course for pre-service elementary teachers (n=51), as they represent the first link in the chain of developing a scientifically literate population. The unit merges a modification of the design cycle, with a version of the learning cycle. We will describe the development of the unit which comprises four hands-on activities aimed at facilitating teachers' learning of the knowledge and skill necessary to solve practical challenges related to energy. Unit addresses energy issues in the context of the design of a house using an Energy3D software, and a guided field visit to a model energy efficient house.

**GN05: 1:40-1:50 p.m. Teachers' Energy Model as a Tool for Interpreting Student Ideas in a Community of Practice\***

*Contributed – Orlana T. Wentink, Seattle Pacific University, 3307 3rd Ave. W Suite 307, Seattle, WA 98119; owentink@spu.edu*

*Amy D. Robertson, Seattle Pacific University*

The Physics Department at Seattle Pacific University supports a group of highly engaged elementary school teachers in a professional learning community (PLC) focused on student learning about energy. Using the lens of communities of practice, we are analyzing video episodes from these PLC meetings to try to understand what supports the teachers' mutual engagement in their joint enterprise of reformed science teaching. In this talk, we illustrate that their co-constructed model of energy is a tool in the teachers' shared repertoire and supports their mutual engagement in reformed science teaching. We highlight the role that this tool plays in the teachers' interpretation of student ideas.

\*Supported in part by NSF Grant No. 1418211.

**GN06: 1:50-2:00 p.m. Teachers' Shifting Interpretations of Inequities in Classroom Participation**

*Contributed – Jennifer A. Radoff, University of Maryland, College Park, John S. Toll Physics Building, rm. 1326, College Park, MD 20740; jennifer.radoff@gmail.com*

*Ayush Gupta, Erin Sohr, Andrew Elby, University of Maryland, College Park*

Math and science education researchers have started documenting how teachers notice and respond to aspects of students' classroom participation. Less is known, however, about how "equitable noticing" (Louie, 2017)—attending not only to the disciplinary substance of students' thinking but also to classroom participation patterns, expressions/enactments of identity, and opportunities to subvert cultural narratives about non-dominant students' difficulties with STEM—is constructed through dialogue between teachers. To start exploring this issue, we analyzed how groups of elementary-school teachers participating in a professional development workshop engaged in collaborative meaning making around equity dynamics in a videotaped classroom discussion about why water expands when it freezes. One group shifted from blaming the teacher in the video for poor classroom management to imagining a wider range of explanations for the inequitable participation patterns they noticed. Our analysis shows how an interaction with another group of teachers may have contributed to this shift.

**GN07: 2:00-2:10 p.m. Development and Implementation of a Graduate Teaching Assistant Training Program**

*Contributed – Jake Shechter, University of Massachusetts - Amherst, 85 N Whitney St, Apt #10, Amherst, MA 01002; jshechter@umass.edu*

*Brokk Toggerson, University of Massachusetts - Amherst*

Many graduate physics programs require graduate students to serve in a teaching assistant (TA) role for at least their first year. The skills that are developed by being a

TA are valuable when working in a research group or in industry, but the connections are not obvious to new graduate students. At University of Massachusetts - Amherst, we have developed and implemented a one hour per week seminar for first-semester graduate students with the aim of helping them make those connections. We gave the new graduate students hands-on experience with tasks directly useful to their TA positions, some basic professional skills, and explored some pedagogical practices and theories. A greater sense of cohort among the incoming class and more initiative in getting into a research group is already observed.

**GN08: 2:10-2:20 p.m. Best Practices in Designing and Teaching Online Graduate Courses**

*Contributed – Bahar Modir, Texas A&M University-Commerce, Department of Physics and Astronomy, PO Box 3011, Commerce, TX 75429; bahar.modir@tamuc.edu*  
*Robynne M. Lock, William G. Newton, Texas A&M University-Commerce*

Research in physics education has shown that interactive learning environments outperform traditional classrooms in student understanding, retention, and persistence. There are inherent challenges in designing online classes within virtual space that induce active thinking by students. In this talk, we give an overview of the best practices for developing active learning environments and explain how we have integrated these aspects in designing and teaching graduate courses in our online Master's program in physics for in-service high school teachers. We discuss course structural design, embedding content into the structure, flexible accessibility of students to the materials, and students' class participation. We also discuss the challenges we encountered and our solutions.

**GN09: 2:20-2:30 p.m. Recruiting Future Physics Teachers with a Summer Enrichment Program**

*Contributed – AJ Richards, The College of New Jersey, 2000 Pennington Rd., Ewing, NJ 08628; aj.richards@tcnj.edu*  
*Nathan Magee, Lauren Madden, Marissa E. Bellino, The College of New Jersey*  
*Melissa Chessler*

The shortage of well-qualified physics teachers is a crisis on a national scale. To address this issue, our institution has successfully applied for a Robert Noyce Teaching Scholarship grant. As part of the programming we've developed from the grant support, we have created a field-based summer enrichment program designed to encourage current students (not on the educational track) to consider transferring to our physics teacher-prep major. The Summer Teacher Exploration Program for Undergraduate Physics (STEP-UP) is a three-week program that gives students a crash course in pedagogy and learning sciences and then allows them the opportunity to design and actually teach lessons in local K-12 classrooms. In this presentation we will describe STEP-UP in detail and discuss how the program changed participants' views on teaching and its viability as a future career path.

**Session TOP05: Graduate Student Topical Discussion**

**Location:** Meeting Room 15    **Sponsor:** Committee on Graduate Education in Physics    **Co-Sponsor:** Committee on Research in Physics Education  
**Time:** 1-3 p.m.    **Date:** Wednesday, August 1    **President:** Lisa Goodhew

*This session is the primary opportunity for student members of the PER community to meet and discuss common issues. While this session is aimed toward graduate students, we welcome undergraduates who are interested in studying PER or curious about life as a graduate student!*

**Session HA: Post-deadline Abstracts I**

**Location:** Meeting Room 2    **Sponsor:** AAPT    **Time:** 3-4:30 p.m.    **Date:** Wednesday, August 1    **President:** Daniel Jacob Doucette

**HA01: 3:00-3:10 p.m. Another Look at Surprising Facts about Earth's Population**

*Contributed – A. James Mallmann, Milwaukee School of Engineering, 20250 W Jeffers Drive, New Berlin, WI 53146-2522; mallmann@msoe.edu*

Information about Earth's past rate of population growth is often incorrectly presented. Many people would find that the mathematical facts about that rate of growth is surprising. Moreover, there are arguments that Earth's current population is not large enough to cause concern. Simple arithmetic can be used to show a surprising flaw in those arguments.

**HA02: 3:10-3:20 p.m. Experimental Design: Cookbook to Inquiry Pathways Students Embark On**

*Contributed – Abigail R. Mechtenberg, University of Notre Dame, 208 Jordan Hall of Science, Notre Dame, IN 46556; Abigail.R.Mechtenberg.3@nd.edu*  
*David McKenna, University of Notre Dame*

At the University of Notre Dame, our introductory labs implemented an experimental design approach over three years with 300+ students/term and 24+ TAs/year. This ED pedagogy uses three thought spheres of doing science: measurements, calculations, and variations. The first thought sphere focuses on what is and how it is measured. It requires understanding the measurement sensors' engineering manual and apparatus drawing. The second sphere is vital to explain in detail what is going to be calculated and how it is going to be calculated (derivation or regression). The third sphere has to do with statistics: what will be varied and how will it be varied. Together there are two analysis pathways: derivation-based (with percent error or error propagation) and regression-based (with RMSE). Using google classroom to document over 20,000 grading comments, 2000 lab reports, 1,500 lab finals and 2,000 evaluations, we define a potential action pathway from novice to approaching expert.

**HA03: 3:20-3:30 p.m. Game-ification of Resistors: Resistance Is Futile**

*Contributed – James G. O'Brien, Wentworth Institute of Technology, 550 Huntington Ave., Boston, MA 02115-5998; obrienj10@wit.edu*  
*Greg Sirokman, Franz J. Rueckert, Derek Cascio, Wentworth Institute of Technology*

In recent years, gamification of education has proven to be an effective paradigm in modern pedagogy. Following the success of the author's previous work with

“Sector Vector,” they now present a new interactive game based laboratory to highlight the basic manipulation and calculation of resistors in circuits. In Resistile, the lesson of basic resistor combinations is delivered in a game based exercise in which a circuit continually evolves. Students are exposed to the creation of a modular circuit which does not always conform to a standard view as might be expected in textbook examples. Together, in an interactive fashion, they must evaluate and analyze a potentially complex overall circuit diagram. Results of student engagement and concept retention have been shown to increase due to the dynamic environment and competitive nature established in the gaming environment. In this talk, we discuss both the concept of the lab-based game itself, as well as the pedagogical implications of the implementation of this gaming medium vs. the traditional resistor combination laboratory exercise.

**HA05: 3:40-3:50 p.m. 9th Grade Physics Students’ Views on Physics Stereotypes**

*Contributed – Johan Tabora, University of Illinois at Chicago/Chicago Public Schools, Department of Curriculum and Instruction, 1040 W Harrison St., Chicago, IL 60607; jtabor3@uic.edu*

This investigation took place in a 9th-grade physics class in a selective-enrollment high school where a “Physics & Society” theme was implemented to study societal issues like gender and race from a physics lens. Students were given assignments asking them about their identities and physics stereotypes. The research questions that this investigation sought to address were: (1) How do 9th-grade students view the role of women and people of color in physics? (2) How do they view society’s capacity to change these stereotypes? The findings showed that students recognize stereotypes and that these need to be addressed. Further studies need to be performed to determine who the students think bears the responsibility for these changes.

**HA06: 3:50-4:00 p.m. Connecting Demonstration Apparatus to the Real World**

*Contributed – Don G. Balanzat, Arizona State University, Department of Physics Box 871504, Tempe, AZ 85287-1504; dbalanza@asu.edu*

Demonstration and experimental apparatus’ bridge the theoretical parts of physics to various external stimuli. In doing so they inspire curiosity, inform of practicality, and bring life and appreciation into what can sometimes be mundane curricula. In this talk, I would like to recount my experiences with various apparatus’ and how they eventually led me to a degree in physics and a career in designing, maintaining, and performing physics demonstrations. I discuss an ever-increasing list of resources for those who are interested in apparatuses, my list of particularly entertaining demonstrations, and the impact of their performance in various settings, academic or otherwise.

**HA07: 4:00-4:10 p.m. LabEscape!**

*Contributed – Paul Kwiat, Department of Physics, University of Illinois at Urbana-Champaign, 601 E John Streeer, Champaign, IL 61820; kwiat@illinois.edu*

Based on APS seed money, we have set up what we believe is the world’s first science-based escape room: LabEscape. By interacting with physics components in the room, the participants uncover clues that allow them to solve the mystery of missing quantum physicist Professor Alberta Schrodberg, and escape! We now have two scenarios operating, each with ~ten different puzzles, all based on physics phenomena, including polarization, refraction, induction, lasers, etc. The room is operated by undergraduate STEM students, and most of the puzzles were created by them as well. Our goal is to show that science can be useful and accessible (no prior background is assumed), as well as beautiful and even fun! To date we’ve had over 3000 ‘agents’ participate, and received near perfect reviews. We’re now exploring ways to expand to an even wider audience, e.g., in other cities, science centers, etc. For more information, see LabEscape.org.

**HA08: 4:10-4:20 p.m. Pre-Service Teachers’ Physics Content Knowledge and Teaching Efficacy**

*Contributed – Mamta Singh, Lamar University, 3635 Grayson Ln., Beaumont, TX 77713-4157; msingh1@lamar.edu*

It is important for elementary pre-service teachers to have strong science content knowledge. If pre-service teachers lack a firm knowledge and understanding of any science topic he or she is teaching, it may lead to development of misconceptions which is one of the major issues in elementary science teaching and learning. Therefore, the purpose of this study was to investigate elementary pre-service teachers’ science content knowledge and teaching readiness. Content knowledge pre-post-tests based on three science domains: Life Science, Physical Science, and Earth, Space Science along with developing lesson plan in three science domains to measure the research objectives. The results indicated that the participants increase their knowledge at the end of the semester and also their teaching efficacy was improved in the post survey. However, results also revealed that participants were more comfortable in designing life science and earth and space science domains’ lessons compared to physical science domain lessons.

**HA09: 4:20-4:30 p.m. Physics Night Study Hall at New Mexico Military Institute**

*Contributed – Yang Yang, New Mexico Military Institute, 101 W College Blvd., Roswell, NM 88201-8359; yang@nmmi.edu*

New Mexico Military Institute is the only state-supported co-educational college preparatory high school and junior college institution in the United States. NMMI’s military boarding school environment requires cadets to develop strong academic skills while they are living in the military framework with tight class schedules starting 7:55 am to 3:30 pm. College physics class usually meets three to four times a week plus two hours of lab section on Tuesday or Thursday. NMMI started a physics club, Physics Night Study Hall, meeting twice a week from 7:00 pm to 9:30 pm supervised and led by professors since 2009. During the physics NSH, homework, exercises, test review problems are discussed and project ideas are shared. Dr. Yang or Dr. Tang will answer questions or conduct review sections during the NSH. The physics NSH is a successful program at NMMI that helps the cadets to reach their academic goals.

**Session HB: Post-deadline Abstracts II**

**Location:** Meeting Room 4    **Sponsor:** AAPT    **Time:** 3–4:30 p.m.    **Date:** Wednesday, August 1    **President:** Kenneth Cecire

**HB01: 3:00-3:10 p.m. Pseudolongitudinal Investigation on Chinese Students’ Categorization of Kinematics and Mechanics Problems**

*Contributed – Qingwei Chen, East China Normal University, North Zhongshan Road Campus: 3663 N. Zhongshan Rd., Shanghai 200062 Shanghai, Putuo District 200062 China chenqingwei1995@gmail.com*

Students’ categorization of physics problems reflects their expertise in problem solving. We conducted a pseudolongitudinal study to investigate the development of students’ categorization ability. Over 250 Chinese students from grades 10 to 12 were asked to categorize 20 problems of kinematics and mechanics into suitable categories based on the similarity of solutions. We compared the categories made by the students in different grades and found that, although students in all three grades performed as novices, their expertise in categorization gradually developed. The results also suggested that the training in problem solving may affect students’ categorization, especially for those in grade 12.



**HB02: 3:10-3:20 p.m. Recent Study of Rising Seas – What Should We Share with Students and Society?**

*Contributed – Celia Chung Chow, (CSU), 9 Andrew Drive, Weatogue, CT 06089; cchungchow@comcast.net*

The important issue or problem facing us NOW is the Climate Change, whether you think it is man-made or not! My study of sea water rising maybe shared with physics/science teachers, their students and general public.

**HB03: 3:20-3:30 p.m. Professional Development linked to AP Redesign\***

*Contributed – Arthur Eisenkraft, UMass Boston, 100 MORRISSEY BLVD # W-4-181, Boston, MA 02125; arthur.eisenkraft@umb.edu*

In 2014, the College Board, based on recommendations of a 2002 NRC report, revised the AP Physics B course. Over five thousand AP teachers had to change what they had taught and how they taught it if they wanted their students to succeed on the new AP Physics 1 and 2 exams. We surveyed those teachers to see how they came up to speed on these changes. We explored whether any of these professional development choices or combinations of choices correlated with gains in student AP scores. We will discuss the range of professional development opportunities that teachers were offered, how they selected the ones they participated in, and how these findings contribute to the accepted model of professional development.

\*This work is supported by the National Science Foundation through the Discovery Research PreK-12 program (DRK-12), Award 1221861. The views contained in this article are those of the authors, and not their institutions, the College Board, or the National Science Foundation.

**HB04: 3:30-3:40 p.m. A Comparative Study on Conceptual Understanding in Physics Lab-1 Between U.S. and Pakistani Undergraduate Students**

*Contributed – Muhammad Riaz, 1) Karakorum International University, Gilgit. 2) Florida Institute of Technology, 207 Walnut Hill Road D-11, West Chester, PA 19382; muhammad.riaz@fulbrightmail.org*

*Manzoor Ali, Department of Physics, Karakorum International University, Gilgit.*

*Syed Mazhar Ali Shah, Department of Computer Science, Karakorum International University, Gilgit.*

*Sadat Rahim, Department of Physics, Karakorum International University, Gilgit.*

A comparative study to determine the relationship between two different populations: U.S. versus Pakistani undergraduate students, on conceptual understanding in Physics-1 laboratory, was conducted during the spring of 2017 and 2018. The data collection was performed in the U.S. during spring semester 2017 at private scientific and technical university, at Melbourne, FL, and the data collection in Pakistan was performed during spring semester 2018 at Karakorum International University (KIU), Gilgit. Moreover, within the context of this study, students' conceptual understanding is measured as the students' percent pre-test scores on the Force Concept Inventory (FCI). Objective: The purpose of this study is to determine the relationship between two different populations: US versus Pakistani undergraduate students, on conceptual understanding as measured by FCI in Physics-1 laboratory. Method: A quasi-experimental study design was used to conduct a comparative study between two different groups of undergraduate students belong from different regions of U.S. and Pakistan. I used a convenient sample of lab sections selected from the accessible population. The accessible population for the US undergraduate students was all students' who registered for Physics Lab-1 in Spring 2017. The accessible population for Pakistani undergraduate students was all students' who registered for Physics Lab 1/3 in Spring 2018. Results: The sample size for U.S. students was 172 whereas, the sample size for Pakistani students was 52. The gender ratio in both groups was 69% male and 31% female. The U.S. undergraduate students' average score on FCI was  $M = 39.36$  with  $SD = 21.37$  out of total score of 100. The Pakistani undergraduate average score on FCI was  $M = 33.33$  with  $SD = 12.09$ . Comparing these students' conceptual understanding between the groups: U.S. versus Pakistan, there is a significant difference on FCI pretests percent scores  $t(223) = 2.57, p < .005$ . Conclusion: The U. S. undergraduate students who registered physics-1 lab have higher conceptual understanding as compared to those undergraduate students who are taking physics lab-1 in Pakistan.

**HB05: 3:40-3:50 p.m. Identifying Discerning Questions to Measure Physics Teacher Knowledge and Gains**

*Contributed – Jacqueline Doyle, Harvard-Smithsonian Center for Astrophysics, 60 Garden St MS-72, Cambridge, MA 02138-6739; jacqueline.doyle@cfa.harvard.edu*

As part of a large national survey of summer professional development programs, we surveyed 491 high school physics teachers' knowledge of their subject and the misconceptions students hold. We identify and discuss the items that performed best at discerning teachers with high and low knowledge, and how these items and ideas may aid in the larger context of effectively measuring the success of professional development programs that aim to increase teacher knowledge.

**HB06: 3:50-4:00 p.m. Transformational Leadership: STEM Educators – A Catalyst for Change**

*Contributed – Jill Latchana, Albert Einstein Distinguished Educator Fellowship Program, 4301 Wilson Blvd., Arlington, VA 22306; jill.latchana@oraу.org*

How can we elevate the voice of educational leaders in federal policy? What does it mean to be an educational leader on a federal landscape? Explore the Albert Einstein Distinguished Educator Fellowship Program, where STEM educators come from all over the U.S. to develop a broader perspective on developing and improving federal programming for students. Participants in this interactive session will join a panel of STEM experts to engage participants in what it takes to become a national leader. Learn how Einstein Fellows bring their insights and experience as K-12 STEM educators to Federal STEM education programs, initiatives, and policy efforts by serving in U.S. Congressional Offices, or the U.S. Department of Energy (DOE), National Science Foundation (NSF), Library of Congress, and the National Aeronautics and Space Administration (NASA). Find out from the panel about the unique professional and career development opportunities available to Fellows.

**HB07: 4:00-4:10 p.m. New Interferometry Lecture-Tutorial Facilitates High Learning Gain in Astro 101**

*Contributed – Chase Hatcher, Dept. of Physics and Astronomy, Univ. of North Carolina at Chapel Hill, 104 Whisperwood Dr., Cary, NC 27518; chatcher10@gmail.com*

*Collin S. Wallace, Dept. of Physics and Astronomy, Univ. of North Carolina at Chapel Hill*

*Edward E. Prather, Center for Astronomy Education (CAE), Steward Observatory, Univ. of Arizona*

*Julia Kamenetzky, Dept. of Physics, Westminster College*

*Timothy Chambers, Dept. of Materials Science and Engineering, Univ. of Michigan*

This paper details the testing of the efficacy of a new Lecture-Tutorial on interferometry meant for introductory astronomy courses. A ten-question multiple choice test meant to measure students' understanding of the material on the Lecture-Tutorial was given to 266 students before and after instruction. Average normalized learning gains were high, 0.71, responses on all items of the test improved significantly after instruction, and the average post test-score 7.71 compared to the average pre-test score of 2.65. Reliability of the test, variability of sample populations, top distractors, and possible sources of error are discussed.

**HB08: 4:10-4:20 p.m. What is Light Telling Us? Spectral Analysis of Astronomical Objects**

Contributed – Eduardo Araujo-Pradere, Miami Dade College, 500 College Terrace, B-225 Miami, FL 33030-6009; earaujop@mdc.edu

James Ley, Miami Dade College

The engagement of students in hands-on activities is an important factor contributing to student success. Through this project, the students use computerized telescopes, astronomical cameras, diffraction gratings, and analytical software to learn about the nature of the atom, properties of astronomical objects, and the motion of objects, effectively becoming a cross-disciplinary project involving Chemistry, Physics, and Astronomy. The activities are grouped as in-class and field experience. First, the students analyze artificial light sources and obtain their spectrum. Then, using the telescopes and cameras, acquire light from stellar sources and apply the same analysis. Finally, they compare the spectrum obtained from both, and observe, for example, that the absorption lines of the hydrogen atom are the same as those observed in the in-class activity with artificial light sources. This confirms for the students the presence of hydrogen atoms in the stars and the universality of the principles of chemistry and physics.

**Session HC: Post-deadline Abstracts III**

Location: Meeting Room 13/14 Sponsor: AAPT Time: 3-4:30 p.m. Date: Wednesday, August 1 President: Charlene Rydgren

**HC01: 3:00-3:10 p.m. What are Dirac Magnetic Monopoles, Where are they, and what they mean**

Contributed – Vic Dannon, Gauge-Institute, Minneapolis, MN 55414; vic@gauge-institute.org

Dirac found that the magnetic charge of a Monopole is  $(1/2)(137)(\text{electron charge})$ . Indeed, it is  $(1/2)(137)(\text{electron charge})(\text{light speed})$ . Dirac opined that this keeps North and South Monopoles locked in dipoles. But a Monopole magnetic field is  $2/10^7$  of the electron's electric field, and a magnet breaks at its dipoles because the distance between dipole poles is way smaller than the distance between poles from different dipoles. Assuming that the Neutron is a mini-Hydrogen Atom where an electron and a proton orbit each other, both orbits are magnetic dipoles. In Neutron decay, each dipole breaks into two Monopoles, the 36eV magnetic energy locked in either dipole splits into a photon with a North magnetic charge, and a photon with a South magnetic charge. If a photon has 18eV energy, its mass is  $\sim(3.5/1000)$  (electron mass), its frequency  $\sim 10^{16}$  cycles/sec, and its wave length is in the Ultra-Violet range. The distance between a North and South Monopoles in an electron orbit dipole is of the order of wave-length in the visible spectrum, a million times larger than the electron orbit around the proton. The magnetic force between the Monopoles is one billionth of the electric force between the Neutronic electron and proton. In the Hydrogen, the electron dipole, or proton dipole energy is undetectable  $1/10^4$  eV. The observation of Dirac Magnetic Monopoles in Neutron Decay will confirm that the electron and the proton that appear in Neutron decay are orbiting each other the same way they do in the Hydrogen Atom. That will prove that the Neutron is a condensed H Atom.

**HC03: 3:20-3:30 p.m. Influence of Reduced Time Pressure on Introductory Physics Exam Performance**

Contributed – Nita Kedharnath, University of Michigan, 37664 Mckenzie Ct., Farmington Hills, MI 48331; nitaked@umich.edu

Tom Finzell, Yuri Popov, Timothy McKay, Heather Rypkema, University of Michigan

Time pressure is widely believed to influence student performance on large, high-stakes exams, reducing overall performance and perhaps exaggerating widespread gendered performance disparities. To explore this possibility, we extended the test-taking time for all 600+ students in an introductory physics course, increasing the long-standing testing time by 50% and recording the time at which each student turned in their exam. All three midterm exams and a final were constructed according to long-standing practice, and steps were taken to support careful comparison of performance to prior terms. In this talk we describe how extended time was used by various groups of students, how overall performance shifted, and how extended time impacted gendered performance differences.

**HC04: 3:30-3:40 p.m. Satisficing in collaborative teaching and learning: Chain strength, weakest link?**

Contributed – Adebajo Oriade, University of Delaware, 217 Sharp Laboratory, Newark, DE 19716; adebanjo@udel.edu

Satisficing [1] is something teachers, learners, and teams do to survive and balance dealing with challenging workload and stringent constraints of time and other resources. We present an approach to collaborative learning involving randomly grouping students in groups of six and within each group of six, creating two groups of three. During problem based group learning, and on semester projects each group of six works together; and during experiment based group work the two groups of three work separately. Periodically each group member evaluates each member of the group including themselves. Consider the statement, "the strength of a chain is in its weakest link". We present a logistic model with identical links, showing that the statement is not always true, in general, the outcome depends on the configuration of links in the chain. Two extremes, given a fixed number of links, are 1) the serial arrangement in which the chain is longest and its strength is in the strength of the weakest link; 2) the parallel arrangement has the shortest length and has the strength of the strongest link. Our implementation explores points in the spectrum of considerations raised by this construct.

[1] Herbert A. Simon, 1978 Nobel Prize in Economics. The concept of satisficing came to our attention in Chapter 3 of "Teaching Physics With the Physics Suite" by Edward F. Redish.

**HC05: 3:40-3:50 p.m. The Multiple Personalities of Embodied Physics**

Contributed – Carey Witkov, Harvard University, 1 Oxford St., #307 Cambridge, MA 02138; witkov@fas.harvard.edu

Embodied learning and cognition, the interdependence of action and thinking rooted in bidirectional signaling between brain and body (e.g., the sensorimotor system), is actively being investigated by several research groups as a means of enhancing student learning in physics. The direct experience of forces as an aid in understanding applications of the force concept is a familiar example, but the scope of embodied physics is much broader and not limited to learning physics in lower grades. This talk provides many examples of embodied physics at the undergraduate level and classifies them to assist teachers recognize opportunities for utilizing embodied learning in the introductory physics classroom and lab.

**HC06: 3:50-4:00 p.m. The Power of Suggestion: Data Driven Argumentation amidst a Backdrop of Lies**

Contributed – John K. Elwood, East Stroudsburg University of Pennsylvania, PO Box 84, Delaware Water Gap, PA 18327; jelwood@po-box.esu.edu

Increasingly, poorly supported opinion competes with evidence-based conclusions in popular scientific discussions. In fact, it might be argued that data driven argumentation is one of the most valuable skills that one can develop in a student. And yet, even after extensive instruction, it remains one of the most elusive. In this five-semester study, we examine the ability of freshman laboratory students to give priority to data in the presence of competing, and manifestly false, claims. The experimental context chosen is that of a simple pendulum measurement on a laboratory course final. We examine the susceptibility of student scientists to suggestion-

induced bias and, digging deeper, ask whether there is overt evidence for post-measurement data manipulation within our student data set.

#### **HC07: 4:00-4:10 p.m. Using Student Authored Problems to Promote Transfer of Learning**

*Contributed – Raymond J. Chastain, University of Louisville, Department of Physics & Astronomy, Natural Science, 102, Louisville, KY 40292; rjchas01@louisville.edu*

Typically, students who struggle in my class do not do so for a lack of effort, but for an inability to recognize the structural similarities between a problem they already know how to work and a closely related problem that appears new to them. In an attempt to strengthen students' ability to transfer between problems that require the same approach, I added a group assignment of Student Authored Problems to the homework portion of a second semester, algebra-based introductory course. I will discuss how the Student Authored Problems fit into the overall homework strategy for the course and the scaffolding used to insure students could be successful in writing them. I will also present students' feedback on the utility and enjoyment of the Student Authored Problem assignments and a brief comparison of exam results to a previous version of the course where only the homework strategy was different.

#### **HC08: 4:10-4:20 p.m. Interactive Lecture Demonstration in a Intro Physics Class for Non-STEM majors**

*Contributed – Maajida L.C. Murdock, Morgan State University, 1700 E Cold Spring, Physics Dept., Baltimore, MD 21250; maajida.murdock@morgan.edu*

Our physics lectures combines traditional lecture-based instruction with active-learning using simple hands-on materials. We have developed some interactive lecture demonstrations that help students grasp the concept of physics in our Introductory physics class for non-science majors. We want to share our observations from these demonstrations that students think actively by challenging their prior knowledge, accepting the explanation of the physics underlying the interactive activity, and then incorporating this new understanding into conversation.

#### **HC09: 4:20-4:30 p.m. How Undergraduates Use Resources and Support Systems to Meet Mental Health Needs**

*Contributed – Edgar F. Ibarra, University of California, Berkeley, 411 N Beverly Sq Ontario, CA 91762; edgar.f.ibarra@gmail.com*

*Kevin A Marroquin, University of California, Berkeley*

Studies of working conditions and their impact on Ph.D. students' mental health has been growing, but there is a dearth of similar studies at the undergraduate level. In this presentation, I will summarize existing literature on mental health studies of undergraduate populations. In addition, I will describe the creation of a mental health survey I plan to administer at a large research institution Fall 2018. This survey will investigate the prevalence of common mental illnesses among undergraduates, what treatment students receive and resources they use to support themselves, and how students understand and discuss mental health. Finally, I will discuss plans for administering the survey to a large population of undergraduate physics students. Ultimately, this work will help raise awareness about mental health issues and improve the learning experiences for undergraduates in physics and other disciplines.

### **Session HD: Post-deadline Abstracts IV**

**Location:** Meeting Room 8/9    **Sponsor:** AAPT    **Time:** 3–4:30 p.m.    **Date:** Wednesday, August 1    **President:** Marla Glover

#### **HD01: 3:00-3:10 p.m. Computational Project for Upper Level Biophysics Course**

*Contributed – Jolene L. Johnson, St. Catherine University, 2004 W Randolph Ave., St. Paul, MN 55105; jljohnsonarmstrong@stkate.edu*

In spring of 2018, I taught Experimental Techniques in Biophysics, which is an upper level physics major elective. As part of the class, the students worked on two main lab projects: a computational lab, and a cell culture and fluorescent protein lab. In this talk I will present an overview of the learning objectives and structure of the class. I will then focus on the random walk computational biophysics lab experiment the students completed. This was my first time teaching both programming in Python and a computational lab, so I learned many lessons which I will share. I will also discuss student outcomes and feedback on the project.

#### **HD02: 3:10-3:20 p.m. Forensic Physics: A Survey Class on the Physics of Forensics**

*Contributed – Ramon O. Torres-Isea, University of Michigan, 450 Church Street - Randall Lab, Ann Arbor, MI 48109; rtorres@umich.edu*

*Naji Hussein, North Carolina State University*

*Frederick D. Becchetti, University of Michigan*

We will discuss our experiences developing and teaching Physics for eight years in the context of forensic sciences. Forensic Physics is a very intensive, two-week long, outreach survey class offered by the Michigan Math & Science Scholars summer program for high-school students at the University of Michigan at Ann Arbor, MI. A wide range of topics are selected for the class, from classical mechanics, electromagnetism, and optics; as well as from atomic, molecular, and nuclear physics. "Crime scenes" are carefully prepared to entice and challenge the students as well as guide the teaching. The class includes brief presentations of the underlying Physics of each topic, with extensive use of experimental demonstrations, followed by laboratory activities which include either the identification of an "unknown" sample or a direct link to the solution of a crime scene. For every topic, at least one forensic case study is discussed explicitly highlighting the application of the Physics concepts.

#### **HD03: 3:20-3:30 p.m. Historical Narratives for Teaching Physics Concepts – A High School Implementation**

*Contributed – Aaron Adair, Malden Catholic HS, 250 Kennedy Drive, Malden, MA 02148-3319; adairaar@gmail.com*

Physics intuitions are well-known to be deeply ingrained and hard to change even when shown to be at variance with Newtonian concepts. PER methods to evolve student mindsets towards more accurate models of the world may benefit from the inclusion of the reasons for those conceptual changes in the first place. A historical narrative that focuses on the reasons why scientists like Galileo and Newton revolutionized physics could turn equations into contextualized discussions with history and their own understanding of the world. A test of high school students in two groups using four questions probing for the medieval impetus concept were used before instruction and then after looked for normalized gains and effect sizes, and model analysis examines the conceptual evolution of the class. The results indicate the inclusion of historical narrative did not hurt those in the experimental group, and analysis indicated overall increased evolution towards Newtonian thinking.

#### **HD04: 3:30-3:40 p.m. Spatial Reasoning and Holographic Curriculum Design**

*Contributed – Mojgan Matloob, Matloob Haghanikar, 214 Duffield St., apt 37N, Brooklyn, NY 11201; holomatloob@yahoo.com*

The forthcoming cutting-edge technologies are holographic advancements, virtual and augmented reality. We are stepping to a new revolutionary phase of human-

computer interaction that can bring out the best of curriculum design. During the last few years, media has been moving away rapidly from 2D to 3D. At the same time, growing body of research in psychometrics and science education literature has reported the high correlation between students' spatial abilities and success in the sciences. The scientific processes are dynamic, and learning sciences not only requires mental visualization of 3D objects but also a 3D mental animation of the scientific process. Using augmented reality we can demonstrate the 3D models as physics ghost guests in the class and move them dynamically. The emerging technologies are wide open for many types of innovation and the emerging possibilities could open a new chapter in curriculum design qualitative research methodologies.

#### **HD05: 3:40-3:50 p.m. Using Excel for Computational Modeling in First-Year Mechanics Course**

*Contributed – John M. Welch, Cabrillo College, 6500 Soquel Dr., Aptos, CA 95003; jowelch@cabrillo.edu*

As part of the lab curriculum in our calculus-based mechanics course at Cabrillo College, students choose a physical system that interests them and model it dynamically using MS Excel. They evaluate and calibrate their models by comparing the results to data from their own or other experiments. This talk will present some of the things we've learned after doing this successfully for several years, including the advantages and disadvantages of using Excel.

#### **HD06: 3:50-4:00 p.m. A Rubric for Assessing Thinking Processes in Free-Response Exam Problems**

*Contributed – Beth Thacker, Texas Tech University, Physics Dept., MS 41051, Lubbock, TX 79409-1051; beth.thacker@ttu.edu*

We designed a rubric to assess free-response exam problems in order to compare thinking processes evidenced in exams in classes taught traditionally and non-traditionally. The rubric is designed based on Bloom's taxonomy. We have data on a number of classes taught by the same instructor, one class more traditionally and one taught in an inquiry-based, laboratory-based setting with Socratic dialog pedagogy. While the two classes may have similar conceptual inventory scores, students in the inquiry-based class demonstrate the use of higher level thinking skills more often. We present results and discuss future research on the value of Socratic questioning pedagogy.

#### **HD07: 4:00-4:10 p.m. Revamping Introductory Lab to Foster Modern Research Skills**

*Contributed – Sean M. O'Malley, Rutgers University - Camden, 227 Penn Street, Camden, NJ 08102; omaltese@camden.rutgers.edu*

*Asa Sallee, Cory Trout, Rutgers University - Camden*

Responding to the national need for a well-prepared STEM workforce. We have implemented an approach to partially address this issue by revamping the way our introductory physics labs are conducted. The approach seeks to provide students with an experience that will engage them in cognitive processes while also providing relevant technical training and exposure to revolutionary technologies. An additional objective of this proposal is to create a learning environment in which the top students can be engaged while simultaneously employing the methods that are effective for the greatest number of students. Details, challenges and results of implementing our approach will be discussed.

#### **HD08: 4:10-4:20 p.m. Teaching Physics to the Arts: The Physics of Hollywood**

*Contributed – James R. Buchholz, California Baptist University, 8432 Magnolia Ave., Riverside, CA 92504; buchholz@calbaptist.edu*

I have created a general education lecture with lab course explicitly designed for undergraduate majors in Film, Theater, Graphic Design, Photography and other media related majors. I will show how I cover many of the same topics covered in a first year physics sequence, but directed toward the visual arts majors. Every topic covered will show how science is involved in the entertainment industry. One example is, for difficult math subjects like Faraday's Law and Ampere's Law, I teach them without math through demonstrations. We then build devices in the lab like microphones and speakers which use these laws. This is a very popular inquiry-based class, that fills early every semester. I will demonstrate some of the labs we do during my oral presentation.

#### **HD09: 4:20-4:30 p.m. The Difference Between Biology and Physics Teachers**

*Contributed – Philomena N Agu, University of Houston, 5807 Candlecreek Drive, Richmond, TX 77469; jolugabe@usa.net*

Texas secondary science teachers have either teaching certification in a subject-specific field or general science. General science teachers may be assigned to teach subjects for which they have little academic preparation. Thus, their sense of efficacy may be impacted. This study aims to compare Personal Efficacy and Outcome Expectancy of general science teachers and subject-specific teachers. Using an adapted Science Teaching Efficacy Belief Instrument, the Personal Efficacy and Outcome Expectancy were assessed for 562 biology and 510 physics teachers in public high schools in Texas. A multiple regression analysis was used to compare Personal Efficacy and Outcome Expectancy of composite teachers with subject-specific teachers controlling for the undergraduate degree major and teaching experience. The subject-specific certification and composite certification did not yield significant differences. However, the majority of composite teachers teach physics. More biology teachers obtain subject-specific certification and earn an undergraduate degree in their teaching field, unlike physics teachers.

#### **Session PST3: Post-deadline Poster Session**

**Location:** Congressional Ballroom Foyer **Sponsor:** AAPT **Time:** 3–4:30 p.m.

**Date:** Wednesday, August 1

Persons with odd-numbered posters will present their posters from 3:00 to 3:45 p.m.; those with even-numbered posters will present from 3:45 to 4:30 p.m. Posters will be available until 4:30 p.m.

#### **PST301: 3:00-3:45 p.m. Embedding Employability in the Undergraduate Physics Curriculum via a Placement In Industry Module**

*Poster – Andrea Jiménez Dalmaroni, Cardiff University, School of Physics and Astronomy, Cardiff, UK CF24 3AA; JimenezDA@cardiff.ac.uk*

In order to answer the demands of a 21st century society, physics education should provide the opportunities for the students to acquire the additional knowledge and practice skills that will let them be more successful in the workplace. At the School of Physics and Astronomy at Cardiff University we are developing a Placement in Industry module for second year undergraduate students to help them gain an experience of how science and technology are used in real-world workplaces. In this presentation, we discuss the current module design, the aims and objectives underlying the Placement module and future improvements.

#### **PST302: 3:45-4:30 p.m. Enhancing the Recruitment, Retention, Training, and Development of Predominantly Hispanic STEM Majors in the Physical Sciences (Chemistry and Physics)\***

*Poster – Edgar D. Corpuz, University of Texas-Rio Grande Valley, 1201 W. University Dr., Edinburg, TX 78539-3416; edgar.corpuz@utrgv.edu*

*K. Christopher Smith, Liang Zeng, University of Texas-Rio Grande Valley*

This project provides for recruitment, retention, and training of talented but financially needy students to pursue degrees at the University of Texas-Rio Grande Valley

(UTRGV) in one of the following STEM fields: BS in Chemistry, BS in Physics or BS in Physical Science (Chemistry and Physics). Scholarship recipients are provided with rigorous training, education and adequate support that will enable them to enter the workforce in a timely manner or to attend graduate school upon graduation. In this poster, we will present the student support activities and other program components that program participants find helpful in their preparation and development, the challenges that the project team faced in recruiting STEM scholars, and the impact of the program components as perceived by program participants. \*Supported in part by NSF- DUE- S-STEM (Award# 1154508)

**PST303: 3:00-3:45 p.m. Exact Solutions for Two Classical Radiation-Reaction Problems**

Poster – Joseph Di Rienzi, Notre Dame of Maryland University, 4701 North Charles St., Baltimore, MD 21210; jdirienzi@ndm.edu  
Richard J. Drachman, NASA Goddard Space Flight Center

Physics is sometimes called “the approximate science,” since so few of its equations are exactly soluble, and none of its measurements are without experimental error. This somewhat discouraging situation can be disheartening to a student of physics, so whenever there is the opportunity to determine an exact solution of a physical system, it should be realized. We will examine two such cases of a system consisting of a charged particle interacting with an external force: in one case with a harmonic force and in the second case with a constant magnetic field. Classical radiation theory suggests that in each situation an additional force should be included from the reaction to the emitted radiation. Despite the fact that the radiation-reaction force is proportional to the third derivative of the particle’s position, both cases considered have exact solutions.

**PST305: 3:00-3:45 p.m. Social Topics in Physics: A New and Intersectional Physics Course**

Poster – Michael Vignal, Oregon State University, Department of Physics, 301 Weniger Hall, Corvallis, OR 97331; vignalm@oregonstate.edu

We created a seminar-style course for undergraduate and graduate students with the purpose of increasing knowledge and awareness of social issues in physics. In our course, titled “Social Topics in Physics,” students meet weekly to discuss readings on social difference and systemic power in physics and other STEM fields. We aim to validate students’ experiences and contributions by inviting students to contribute ideas and articles for the class and to shape the weekly discussions by connecting the readings to their own experiences. Additionally, we try to focus on intersections of difference and power in a way that promotes curiosity and compassion. This poster details the different resources and considerations that have made this course successful.

**PST306: 3:45-4:30 p.m. Graphically Finding Wavelength Using Small Slit Spacing Diffraction Gratings**

Poster – Patricia E. Allen, Appalachian State University, Physics and Astronomy Department, Boone, NC 28608-2106; allenpe@appstate.edu

For diffraction gratings with small slit spacing (500 lines/mm and above), few orders of interference maxima are available for calculating visible wavelengths. Such limited data can result in inaccurate and imprecise values for wavelengths. A variation on the “standard” diffraction grating laboratory is to graph average distance of first order fringes from the central maximum ( $x_{avg}$ ) as a function of grating to screen distance ( $L$ ). The resulting plot is linear, with the slope indirectly dependent on wavelength and slit spacing. With a little algebra, the wavelength (or slit spacing) can be calculated from the slope, often with high accuracy and precision. A sample experimental set-up will be presented, along with results from an undergraduate lab activity.

**PST307: 3:00-3:45 p.m. Integration of Computation in Quantum Mechanics**

Poster – Haiying He, Valparaiso University, 1610 Campus Drive, Dept. of Physics and Astronomy, Valparaiso, IN 46385; haiying.he@valpo.edu

Quantum mechanics (QM) is often taken as a very abstract subject. Many concepts are even beyond intellectual comprehension for most undergraduate students. To overcome these obstacles and develop a better appreciation of these “true” governing rules in the quantum world, I have tried to make the examples/problems concrete and alive by using computational tools. Numerical calculations and graphical presentations are often adopted in both class instruction and students’ practice. In the second semester of QM, we have gone beyond the prototype questions and introduced methods to tackle more realistic problems. A computational application project is assigned to students to compute and compare the ionization potentials of single atoms using different approximation methods (including both the variational principle and the perturbation theory). Students were introduced to a quantum chemistry program Gaussian09 to conduct all their numerical calculations. A graphical program Gaussview was also used to demonstrate the wave functions (atomic orbitals).

**PST308: 3:45-4:30 p.m. Learning Assistant Program Impact for Non-Traditional Transfer Physics Majors**

Poster – Patrick L. Chestnut, Rowan University, 31 Deerfield Circle, Sewell, NJ 08080; chestnut@rowan.edu

Rowan University, a public school located in southern New Jersey, serves a high number of non-traditional transfer students. Almost half of all upper division students within the Department of Physics and Astronomy are transfer students, and one-tenth are over age 24. This population often faces unique challenges compared to traditional students matriculating directly from high school. Our team will present findings from interview data with transfer students who serve the department in the role of learning assistants within introductory physics courses. Analysis of interview data provides insights into challenges and opportunities this population faces and manners to which the LA program has been beneficial to student development.

**PST309: 3:00-3:45 p.m. Advancing Middle School Students’ Ability to Control Variables\***

Poster – Edana Wilke, University of Cincinnati, 2600 Clifton Ave., Cincinnati, OH 45221; wilkeea@mail.uc.edu  
Kathleen Koenig, Krista E. Wood, University of Cincinnati  
Lei Bao, The Ohio State University

An important skill in the experimental design process, as well as in many decision-making processes, is the ability to identify and control variables. This ability is generally slow to develop unless explicit instruction is provided. In an effort to improve these abilities in middle school students, a windmill engineering design project was developed to lead students through activities focused on the cyclic process of scientific inquiry. Controlled experiments built upon one another and results of initial experiments were to inform subsequent experiments; enabling students deliberate practice in experimental design. The lesson was completed by over 1200 middle school students in Spring 2018 at three schools. Pre- and post-testing was conducted using a set of questions designed and validated for this purpose. This presentation will showcase what was learned about student abilities prior to the activity as well as gains made as a result of the lesson.

\*Supported by NSF DRK-12 Grant #1417983.

**PST310: 3:45-4:30 p.m. Developing Basic Physics Instruction to Enhance Students’ Performance in Problem Solving**

Poster – Hamdani Hamdani, Tanjungpura University, Jl Profesor H Hadari Nawawi Pontianak, Pontianak 78124 Indonesia; hamdani052185@gmail.com

Basics physics course is very fundamental in our department (physics education, Tanjungpura University) because this course is the foundation for students to learn advanced physics courses such as mechanics, thermodynamics, electricity and magnetism, modern physics etc. To help students learn basics physics concepts, we have developed this course involving physics problem-solving questionnaire (PPSQ), recitation class, physics representation worksheet (PRW). A problem-solving survey was designed to investigate students' perception. Furthermore, while learning force concepts (Newton's laws), we have designed worksheet to facilitate students understanding force concepts during recitation class. Before and after instruction, we asked students to fill out the survey. Finally, we asked students to solve 11 FCI items and two open-ended questions at the end of the lesson.

**PST311: 3:00-3:45 p.m. Improving Elementary School Students' Scientific Character through Physics Lessons Focusing on Cooperative Relationship**

Poster – Ilkyun Nam, Daegu University, 201 Daegudae-ro Gyeongsan-si, Gyeongsanbuk-do 38453, Republic of Korea; nik271466@gmail.com  
Sungmin Im, Daegu University

In this case study, we investigated the improvement of elementary school students' (4th grade, no. 25) scientific character through physics lessons focusing on the cooperative relationship. Students were involved in a series of physics lessons on Kapla construction based on basic principles of statics. The lesson was organized by Kagan's cooperative learning structure and Jigsaw model, and rules of cooperative communication such as making eye contact, using the polite expressions, and addressing someone respectfully were applied. The authors utilized Cultural Historical Activity Theory as a theoretical framework to describe and investigate the improvement of students' scientific character through the physics lessons. Based on this result, we inferred some suggestions for the establishment of relations between physics lessons and the values of our human lives.

**PST312: 3:45-4:30 p.m. Letters to Self and Future Student for Easing Physics Anxiety**

Poster – Terry L. Ellis, Jacksonville University, 2800 University Blvd., Jacksonville, FL 32211-3394; tellis@ju.edu

Metacognition (the awareness and understanding of one's own thought processes) and self-efficacy (believing in one's own ability to accomplish the tasks necessary to succeed) can have a positive impact on the self-confidence and motivation of students whose learning is hindered by physics and math anxiety. In order to alleviate some of the stress and to encourage self-empowerment of students in an introductory algebra-based physics course, new students receive a letter from a past student and write a letter to their mid-term-self describing their hopes, concerns, and outlining a plan of action. At mid-term, they write a letter to their end-of-term-self describing habits that have led to success, and habits they need to change to get back on track. Finally, at the end of the course they write a letter to an incoming student offering encouragement and tips on how to succeed in the course.

**PST313: 3:00-3:45 p.m. Interactive Lecture Demonstrations for Teaching Calculus-based Kinematics**

Poster – Melia E. Bonomo, Rice University, Dept. of Physics and Astronomy, MS-61, PO Box 1892, Houston, TX 77251; meb16@rice.edu  
Michael W. Deem, Rice University

Kinematics is a benchmark topic in introductory physics, however students often enter and leave these courses with a wealth of misconceptions. Teaching strategies that do not suitably address these misconceptions often encourage students to adopt a "plug and chug" approach for solving kinematics problems. Furthermore, the lack of a sufficient background in calculus is a limiting factor for student understanding. Here, we describe interactive lecture demonstrations that integrate mathematical derivations with basic running and jumping activities, without requiring specialized equipment or technology. The goal is to bring students up to speed on relevant concepts in calculus and to help them develop an intuitive understanding of the mathematics of motion. These teaching methods are suitable for high school or college physics classrooms, including those in low resource settings.

**PST314: 3:45-4:30 p.m. Maths Skills and Attitude: Success on Quantum Mechanics Courses?**

Poster – Inkeri Kontro, Department of Physics, University of Helsinki, P.O.B. 64 Helsinki, 00014 Finland; inkeri.kontro@helsinki.fi  
Elina Palmgren, Department of Physics, University of Helsinki

Knowledge of mathematics, e.g. linear algebra, is important for physicists learning quantum mechanics. But does it make a difference whether this knowledge is acquired before or simultaneously with the physics content? And what is the role of students' beliefs about their abilities to understand quantum mechanics? To study this, we administered a mathematical pre-test and a questionnaire measuring self-efficacy beliefs and correlated these with the learning outcomes of students on an introductory quantum mechanics course at the University of Helsinki. The preliminary results indicate that neither the mathematical skills at the beginning of the course nor the self-efficacy beliefs predict accurately performance in neither exercises nor exams. The most important predictor seems to be the study track: students who have selected "theoretical physics" both feel better about their skills and do better than their "physics" peers, despite starting at equal levels of mathematics skills.

**PST315: 3:00-3:45 p.m. Perceptions of K-12 Science Teachers as Leaders in Educational Policy in the U.S. and Abroad**

Poster – Rebecca E. Vieyra, University of Maryland, 225 C St. SE, Apt. B, Washington, DC 20003; rvieyra@aapt.org

Although master science teachers have been called upon in a limited way through various U.S. initiatives for curriculum, standards, and assessment development, teacher voice in broader, more systemic policy-making about science education issues beyond classroom practices is routinely absent. The author attended two conferences associated with science teacher leadership: (1) the U.S. Council of State Science Supervisors and the (2) Inter-American Teacher Education Network of the Organization of American States. Significant differences were observed in the perception of teachers as contributors to policy issues across states and countries, evidenced by agenda topics and conversational language about teachers' role in policy-making. Findings and implications for the enhancement of the U.S.'s perceived role for teachers will be discussed, as well as opportunities for educational research on science teacher leadership programs.

**PST316: 3:45-4:30 p.m. Probing Student Understanding of Conceptual Introductory Physics Problems**

Poster – David P. Waters, St. Louis College of Pharmacy, 4588 Parkview Place, St. Louis, MO 63110-1088; david.waters@stlcop.edu

Students appear to understand physics concepts while in class, yet when a new conceptual question is posed, they do not always answer the question correctly. We hope to understand the reason for these difficulties in order to improve instruction and assessment. In this pilot study, we formed three groups of two students each who had previously taken physics. These students attempted to solve a number of multiple-choice physics questions on their own, and then talked through their reasoning with their partner to come to an agreement on the correct answer. These sessions provided great insight into their understanding and subsequent application to solve conceptual physics problems.

**PST317: 3:00-3:45 p.m. Reasons for Low Enrollment of Girls in High School Physics**

Poster – Traves O'Neill, Vista Unified School District & California State University, San Marcos, 1 Panther Way, Vista, CA 92084-3128; Traveso'neill@vistausd.org

Using a digital survey consisting of 20 questions including Likert scale and short answers forms, this study investigates the reasons girls are enrolling in physics at lower rates than boys at one comprehensive high school in Southern California. There were 485 science student responses validated and analyzed ranging from grade 10-12, including 262 girls and 211 boys. The data suggests seven key findings including (1) girls perceive physics as less interesting, (2) have lower self-efficacy in math and science, (3) perceive physics as harder, less fun, and less applicable, (4) have less interest in physics related college majors, (5) are more likely to enroll in courses that prepare them for college, (6) are less likely to take a science courses to explore personal interests, and (7) are less likely to take a science course to be with friends.

**PST318: 3:45-4:30 p.m. Technical Writing and Letters Home**

Poster – Charles L. Ramey, Texas Tech University, Physics & Astronomy Dept., Box 41051, Lubbock, TX 79409; charles.ramey@ttu.edu

Dimitri Dounas-Frazer, University of Colorado Boulder

Beth Thacker, Texas Tech University

Communication is an important skill in all fields of STEAM, including physics lab courses. The AAPT Committee on Labs recently identified 'communicating physics' as one of six major learning outcomes for undergraduate physics labs. At Texas Tech University, we have recently redesigned the Modern Physics Lab to develop students' competence with written communication, among other goals. To support students' writing skills, we implemented the pedagogical method Letters Home in an upper division lab. The Letters Home activity provides students with the opportunity to practice writing skills, first, in the form of letter to a non-physicist then gradually to a graduate student or professor in the physics department. We used the AAPT guidelines to inform our development of an a priori coding scheme with 12 unique categories that highlight learning outcomes such as: presents experimental and/or theoretical methods, analyzes and/or evaluates evidence, and present and/or evaluates conclusions. We conducted a case study of 6 students, each of whom completed 6 writing assignments. Our case study allows us to describe how students oriented to the Letters Home activity and how their writing progressed over the course of the semester. We are finding that there are major structural and content similarities and differences between letters and reports, and that most students in our study tailor their writing to a non-physicist by making only minor/superficial modifications to the traditional report format.

**PST319: 3:00-3:45 p.m. Using an Electric Guitar as a Vehicle to Teach Introductory Electronics Concepts**

Poster – Debbie A. French, Wilkes University, 84 West South St., Wilkes-Barre, PA 18766; frenchd14@yahoo.com

Sean Hauze, San Diego State University

Doug Hunt, Southern Wells High School

Thomas Singer, Sinclair Community College

Electricity/electronics is a topic many students may find challenging. Additionally, instructors may be searching for ideas to teach electronics in an engaging way. The STEM Guitar Project (NSF #1700531) provides faculty professional development (PD) institutes to K-16 teachers. At the institute, teachers receive 50 hours of PD where they build solid-body electric guitars and receive instruction on how to use the guitar to teach integrated STEM concepts such as electricity/electronics. The STEM Guitar grant has twelve core Modular Learning Activities (MLAs); one of which focuses on the circuitry and physics of the electromagnetic pickups. A description of the MLA will be given along with pre/post test scores from 173 participating students. Analysis of these test scores show statistically significant learning gains ( $p < 0.005$ ). The results of this work show that the guitar may be used as an effective vehicle to teach integrated STEM concepts such as electricity/electronics.

**PST320: 3:45-4:30 p.m. To Study or to Sleep: Changing Students' Choices**

Poster – Vincent P. Coletta, Loyola Marymount University, 6364 W. 77th St., Los Angeles, CA 90045-1373; vcoletta@lmu.edu

Two studies were conducted with students in introductory physics classes. In the first study, though students were urged to get sufficient sleep the night before the final exam, few students did and there was a significant positive correlation between hours of sleep and final exam score. In the second study the following semester, students were shown the results of the first study. Showing current students the negative effect that sleep deprivation the night before a final exam had on exam scores in a prior class changed the current students' sleep choices the night before their own final exam. Once students saw evidence that staying up all night studying for a final exam would likely hurt their score on the exam, students no longer made that choice.

**PST321: 3:00-3:45 p.m. Hollywood Physics**

Poster – Luis G. Mijangos-Fuentes, Universidad del Valle de Guatemala, 18 Avenida 11-95 zona 15, Vista Hermosa 3 Guatemala, GT 01015; lgmijangos@uvg.edu.gt

The movies that students watch have the potential of becoming incredible useful educational instruments. We can use them to teach more efficiently the concepts that they usually consider complex. In this poster, we show a methodology that we use in our introductory physics courses. It consists in carefully selecting 3 popular and recent movies or cartoon scenes and asking a question about it that requires quantitative analysis to answer. The students are required to investigate, to do measurements, and to make reasonable assumptions to answer the question. We have measured the impact and efficacy of this methodology by asking students about their learning experience. The results show that 55% of the students consider that they understood better the physical concepts because of this activity, and 28% of them think that the most important learning aspect reinforced by this activity is how to apply the physical concepts to the real world.

**PST322: 3:45-4:30 p.m. Supporting Language Minorities with Online Resources**

Poster – Inkeri Kontro, University of Helsinki, P.O.B. 64, Helsinki, 00014 Finland; inkeri.kontro@helsinki.fi

The University of Helsinki offers BSc degrees in Physics in Finnish and Swedish, with the Swedish speaking students making up <10% of the student population. Most introductory courses run in both Swedish and Finnish, but due to lack of resources, some important courses are offered in Finnish only. In 2017, parts of the introductory mathematics courses started utilizing a flipped classroom model using online resources. In addition to (Finnish) lectures and pen-and-paper exercises (in both languages), we introduced instruction videos and online exercises. The translation of the online materials required only a little additional effort. Both students and staff felt that the online materials were a helpful addition, and they provide a cost-effective way to offer the students the course partially in their preferred language.

**PST323: 3:00-3:45 p.m. A New Method for Teaching Introductory Labs to Enhance Preparation and Develop Critical Thinking Skills**

Poster – Cory J. Trout, Rutgers University - Camden, 10 Canterbury Pl., Camden, NJ 08081; cory.trout@rutgers.edu

Asa Sallee, Sean M. O'Malley, Rutgers University - Camden

An alternative approach to introductory physics lab was employed and studied in an attempt to better prepare students for future work in the STEM fields. Students will learn to operate both essential and versatile tools commonly seen in industry and research labs. Rather than giving step-by-step instructions, the students are asked to design and construct their own experiments to prove physical laws and concepts commonly seen in an introductory physics class. This approach is intended to stimulate the student's creativity by encouraging them to combine their understanding of physics with the tools provided for them to reach a well thought out conclusion. We will further discuss the details of this method, the evaluation of our approach, and future implementations.

**PST324: 3:45-4:30 p.m. A Rubric for Assessing Thinking Processes in Free-Response Exam Problems**

Poster – Beth Thacker, Texas Tech University, Physics Dept., MS 41051 Lubbock, TX 79409-1051 beth.thacker@ttu.edu

We designed a rubric to assess free-response exam problems in order to compare thinking processes evidenced in exams in classes taught traditionally and non-traditionally. The rubric is designed based on Bloom's taxonomy. We have data on a number of classes taught by the same instructor, one class more traditionally and one taught in an inquiry-based, laboratory-based setting with Socratic dialog pedagogy. While the two classes may have similar conceptual inventory scores, students in the inquiry-based class demonstrate the use of higher level thinking skills more often. We present results and discuss future research on the value of Socratic questioning pedagogy.

**PST325: 3:00-3:45 p.m. An Analysis of the Efficacy of Context Rich Group Problems**

Poster – Paul Bergeron,\* University of Utah, 49 S 800 E #18, Salt Lake City, UT 84102-1239; bergeron.physics@gmail.com

Context rich group problems are designed to both critically engage students' understanding of physics as well as bolster it through collaborative interactions. Such problems are increasingly used in the discussion sections of the introductory physics series at the University of Utah. During their initial implementation, employment of this teaching technique was not universal, and saw, for example, only one discussion section for a given lecture utilizing them. This presents a unique situation, where one cohort amongst a larger class is taught with context rich group problem sessions for one semester, whereas the entire class is taught with them during the subsequent semester. I will present a simple analysis of these two classes' exam scores to provide some insight into the efficacy of context rich group problem sessions.

\*Sponsored by Professor Jordan Gerton, University of Utah

**PST326: 3:45-4:30 p.m. Difficulties and Challenges of Physics and Chemistry in School**

Poster – Oscar Jardey, Suarez Fundación Universidad, Autónoma Colombia Calle 12 b No 4-31, Bogotá, AA 11001 Colombia; oscar.jardey.suarez@gmail.com

Liz Patricia, Suárez Secretaria de Educación de Bogotá

In Colombia, Physics and Chemistry are compulsory subjects in high school. The formation in natural sciences must be oriented to the appropriation of some concepts to explain the processes of the nature from the observation, systematization, argumentation having in perspective the development of the scientific thought. What is a great challenge for teachers who meet daily with deficiencies in concepts of mathematics and communication skills, as well as the lack of commitment and responsibility of students; which results in reprobation that exceeds, in some cases, 50% and some poor results in the national census tests. The above constitute the motivations to reflect and rethink the activities of classrooms when teaching physics or chemistry, as well as to weigh to what extent to comply with some programmatic contents and the objectives demanded by the MEN are the solution to overcome the challenge posed in widely diverse socioeconomic and emotionally diverse communities

**PST327: 3:00-3:45 p.m. K-12 Science Outreach in South Carolina**

Poster – Susan M. Engelhardt, South Carolina Governor's School for Science and Mathematics, 401 Railroad Ave., Hartsville, SC 29550; engelhardt@gssm.k12.sc.us

The South Carolina Governor's School for Science and Mathematics (GSSM) is a public residential high school for 11th and 12th graders interested in pursuing an intense education in the STEM fields. Additionally, GSSM supports the following outreach initiatives that will be described in this poster: residential camps (GoSci-Tech), day camps around the state (iTEAMS & CREATEng), after school programs (ENGAGE & SPARK), a dual-credit virtual engineering program (Accelerate), an annual community STEM event (INSIDE GSSM), and school group visits to GSSM to do STEM activities.

**PST328: 3:45-4:30 p.m. Supplemental Activities to Transform Traditional Exams Into Powerful Learning Experiences**

Poster – Jordan M. Gerton, University of Utah, 115 South 1400 East, RM 201 Salt Lake City, UT 84112; jgerton@physics.utah.edu

Traditional introductory physics exams are designed to probe efficacy across a range of topics, but may also challenge students in unintended ways. For example, the time-bound nature of most exams may disadvantage language learners, students who process information more deliberately, and those with test anxiety. Non-traditional assessment approaches, such as group exams/quizzes, engage students in learning as part of the assessment process and may address some of these issues, but may also be difficult to implement in some contexts. We present some supplemental activities that are meant to transform traditional exams into powerful learning experiences for all students. Some examples include publishing the authentic exam scenarios well in advance of the test date, having students produce exam solutions in small groups immediately after an exam, and having students participate in a gallery stroll of the group-produced solutions. We seek feedback on how to study the efficacy of this approach.

**PST329: 3:00-3:45 pm. Use of smartphones and Tracker in Modern Physics Experiments**

Poster – Munir Pirbhai, St. Lawrence, University, 23 Romoda Dr., Canton, NY 13617-1423; mpirbhai@stlawu.edu

Measuring the charge-to-mass ratio of the electron is a classic experiment often performed by students in Modern Physics courses. It relies on measuring the radius of curvature of electrons as they move in a magnetic field of known strength. In this work, we show how these parameters can be determined with a smartphone and the freeware Tracker. PST330: 4:20-4:30 p.m. Operationalizing Identity in a Survey of Students from Laboratory Classes

**PST330: 3:45-4:30 p.m. Operationalizing Identity in a Survey of Students from Laboratory Classes**

Contributed – Carissa Meyers, Wright State University; myers.284@wright.edu

Kelsey Funkhouser, Marcos D. Caballero, Paul W. Irving, Vashti Sawtelle, Michigan State University

This project explores student responses to the first iteration of a survey, which is being built to measure physics identity from a practice perspective in physics lab



courses. Identity is a multidimensional construct of how a person perceives themselves and how they position themselves within a community or environment. Part of the process of measuring identity is determining what constitutes an identity statement, and what factors help separate these statements from the rest of the response. We present an analysis of an open-ended survey given to students enrolled in an introductory physics laboratory class. Student responses were analyzed and coded for emergent themes, which were discovered in the student's interpretations of questions regarding physics lab practices. In this poster, we present progress on both the coding scheme that emerged, and set of question stems for a future iteration of the survey that targets physics identity in lab classes.

### Session PERC: PERC Bridging Session

Location: Renaissance Ballroom

Sponsor: PERC

Time: 3–4:30 p.m.

Date: Wednesday, August 1

Presenter: PERC

### Teachers as Learners: Seeing “Wonderful Ideas” in Preservice Teacher thinking

*Rosemary S. Russ*

We are in a time of science education research, and in PER specifically, when nearly all scholars enthusiastically embrace a constructivist perspective on learning. At the heart of that perspective is the assumption that people construct new knowledge from existing knowledge. Duckworth's notion of learners having “wonderful ideas” elucidates and extends constructivism by explicitly reminding researchers that the old knowledge learners build from, while potentially used incorrectly, is in-and-of itself valuable and productive. That is, learner's existing knowledge is wonderful, and indeed must be wonderful, if they are to build their new knowledge from it. Although researchers and educators have embraced constructivism for our students across K-16, the field has yet to apply that same perspective to our understanding of teachers. It continues to be commonplace to treat teachers either as blank slates who come to our undergraduate courses with no useful knowledge, or as novices characterized predominantly by deficits we need to fix. In this talk, I suggest that supporting teachers in their own learning – both of physics and of pedagogy – must involve seeing them first as learners with wonderful ideas. I will argue for this (seemingly obvious yet not actualized in research!) theoretical stance by presenting data that illustrates teachers' wonderful ideas across several contexts and settings. I will also demonstrate the continuity between those existing wonderful ideas and those the field considers to be sophisticated and desirable. Finally, I will explore implications of this stance for our work with physics teachers both in practice and research.

### The Multimodal Interactional Work of Having Wonderful Ideas

*Benedikt W. Harrer*

Learning physics is socially organized through interactions with peers and more competent others. Instructors' and peers' assessment of and responsiveness to learners' ideas in the moment is critical for the collaborative construction of knowledge in physics. However, we still know little about how instructors and learners negotiate the value and productiveness of ideas. While to an outsider, some of the ideas physics learners discuss do not seem immediately valuable or productive for the problem being solved, Duckworth encourages us to pursue an ‘insider's view’ on how a learner experiences their ideas. Building on Duckworth, I pursue an ‘insider's view’ to better understand how peers and teachers experience each other's ideas. In particular, I examine the interactional methods and resources participants use to express ideas and to mark their own or others' ideas as wonderful or not-so-wonderful. I demonstrate how participants rely on a variety of multimodal communicational tools, including speech, words, gestures, and whiteboard inscriptions to negotiate wonderfulness, extending our current understanding of how peers and instructors are responsive to physics ideas in the moment.

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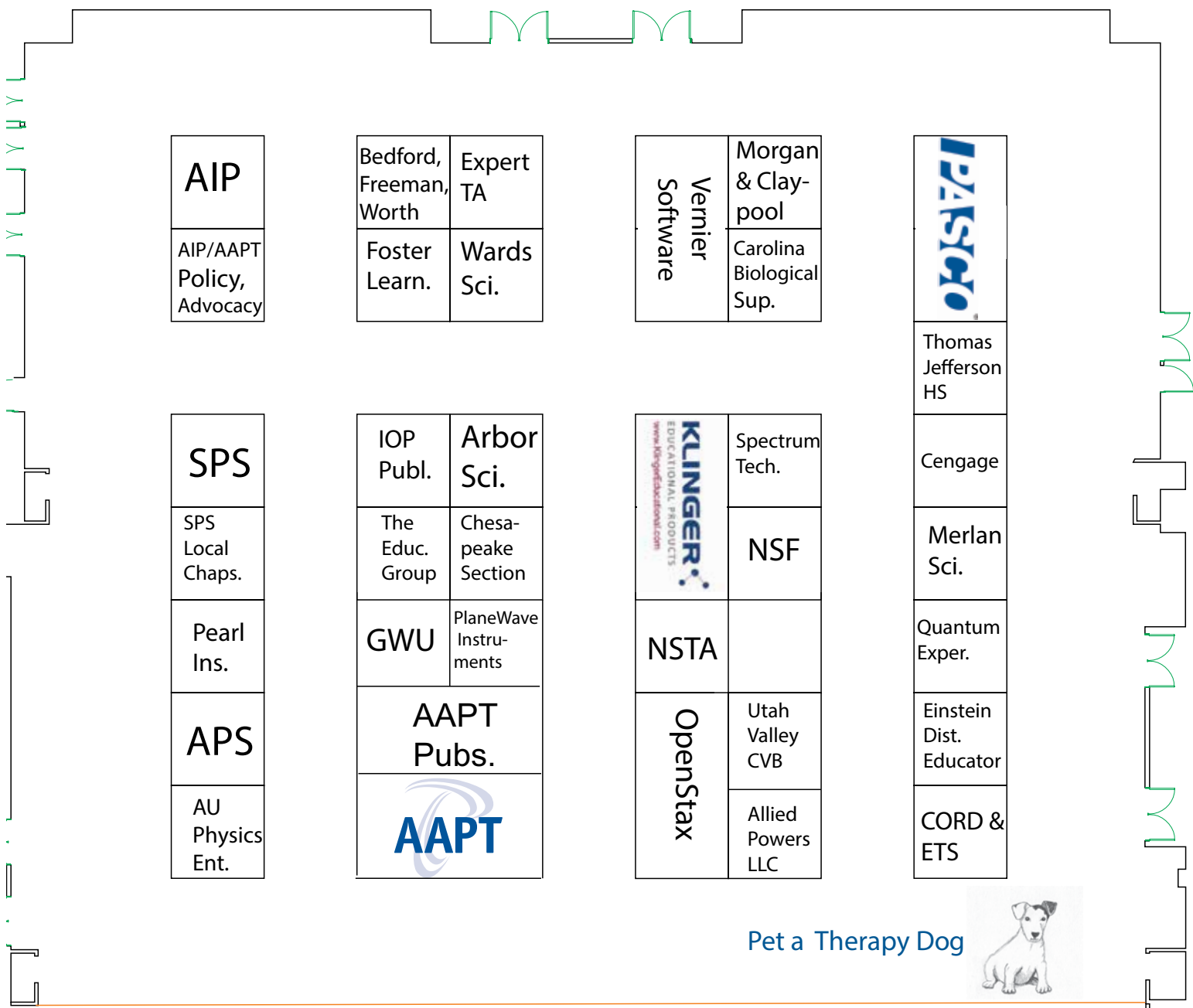
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 Yu, Yunwei, PST1F03  
 Yuan, Hua, EK02, PST2B08  
 Zabriskie, Cabot, FA01, FA08, FA09, PST1C43, PST1C44, PST1D06  
 Zajac, Richard A., DD02, PST2A02  
 Zamarripa Roman, Brian, EH04  
 Zamora, Ryan J., EG04  
 Zavala, Genaro, PST2C06  
 Zeng, Liang, PST2C47, PST302  
 Zeng, Yi, PST2C47  
 Zengel, Keith, AF06  
 Zhang, Muxin, DA06  
 Zhang, Xingchen, PST2D01, PST2D19, PST2D20, FD12  
 Zhou, Changgong, EC08  
 Zhu, Guangtian, DL08  
 Zhu, Hongzhi, EK04, PST1B20,  
 Zich, Raymond, EA10, PST1C33, PST2C02, PST2C46  
 Zimmerman, William, PST1B15  
 Zisk, Robert C., GB09  
 Zohrabi Alace, Dina, AA12  
 Zollman, Dean, BH11  
 Zu, Tianlong, FB03  
 Zwicker, Andrew, FF04  
 Zwickl, Benjamin, CB08, EH11, PST1C54, CA08

# Renaissance Hotel

## Grand Ballroom North/Central

# Exhibit Hall

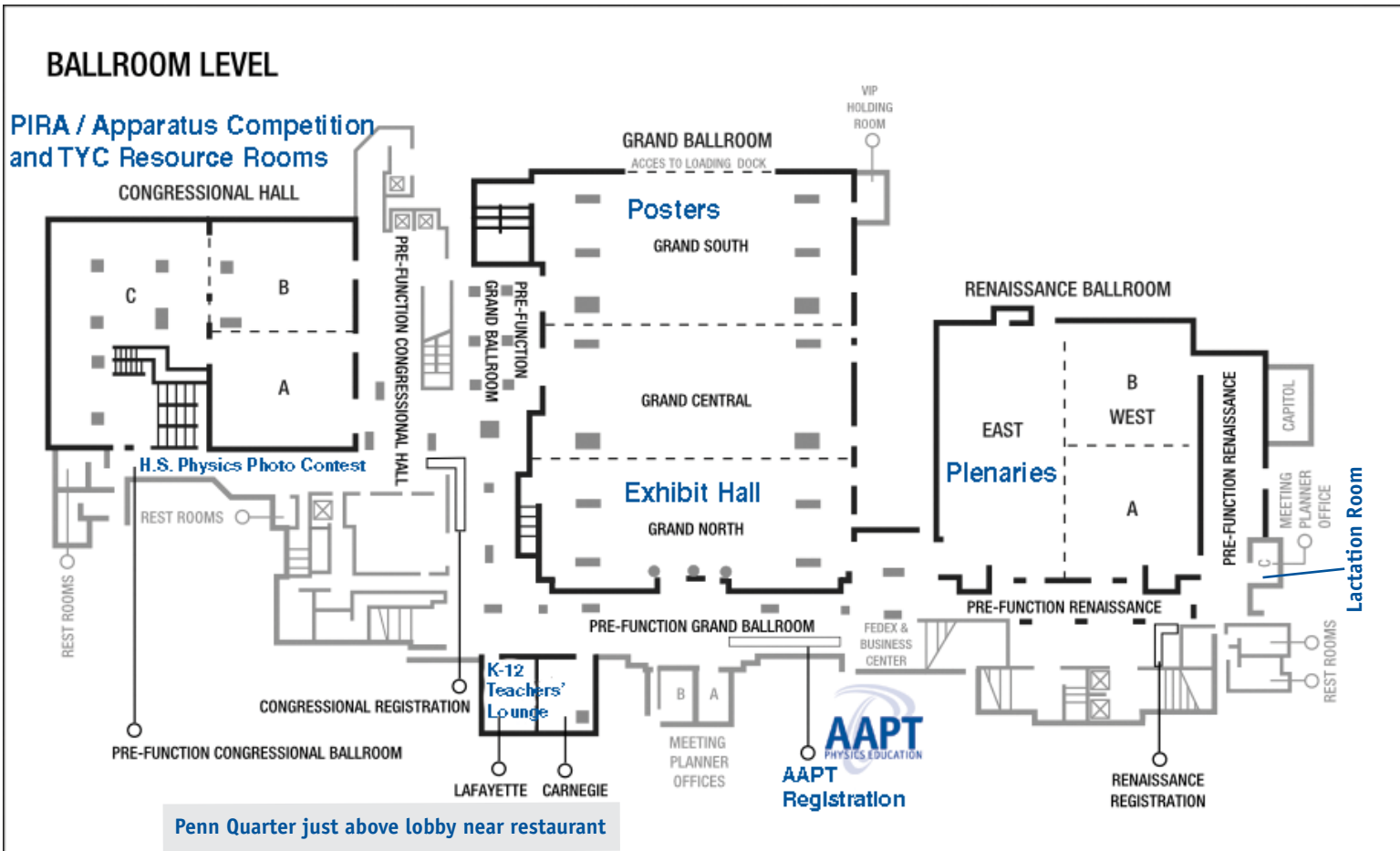
ENTRANCE



### HOURS FOR EXHIBIT HALL

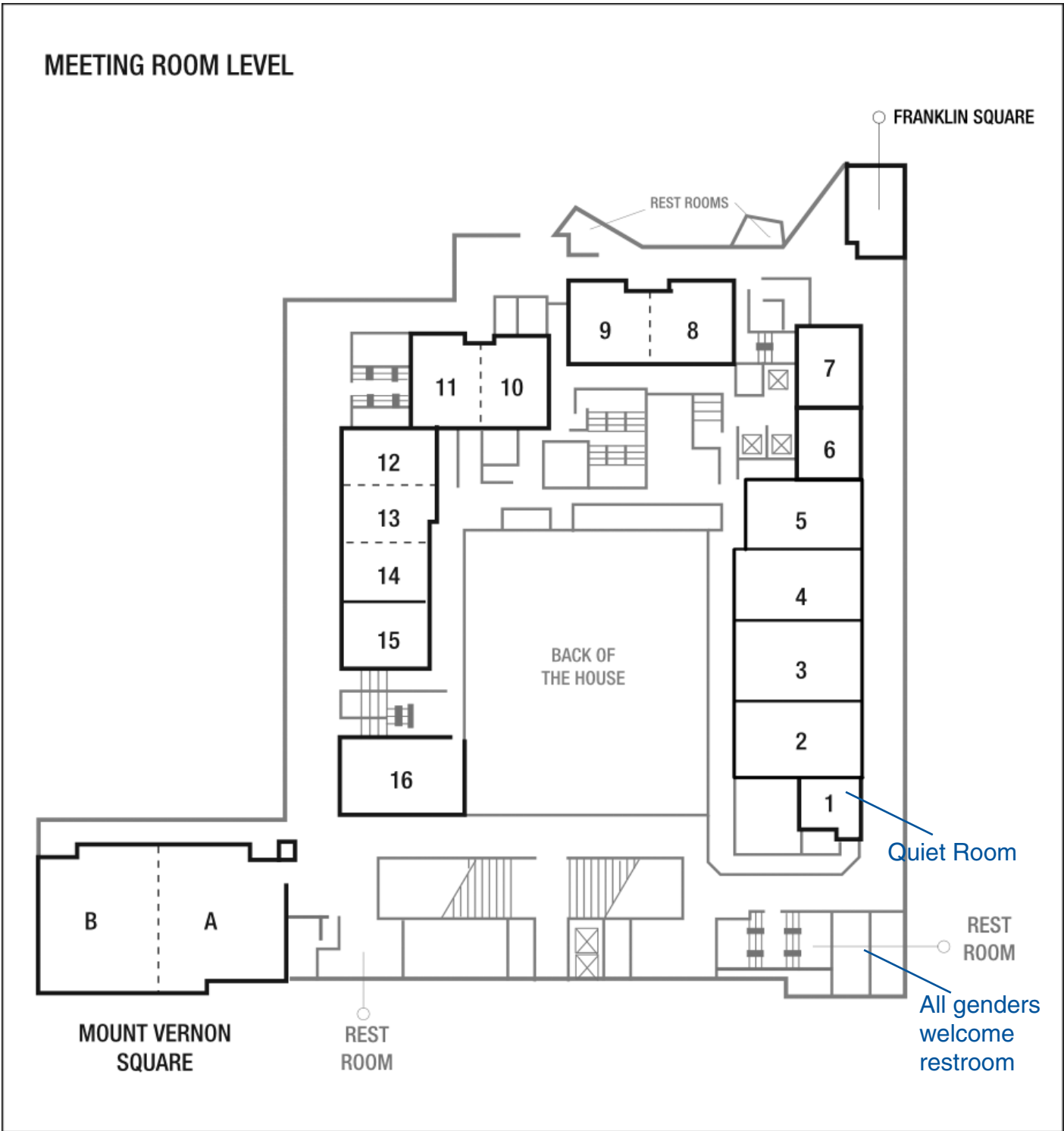
Sunday: 7–9 p.m.  
 Monday: 10 a.m.–5 p.m.  
 Tuesday: 10 a.m.–4 p.m.

# Renaissance Hotel Ballroom level



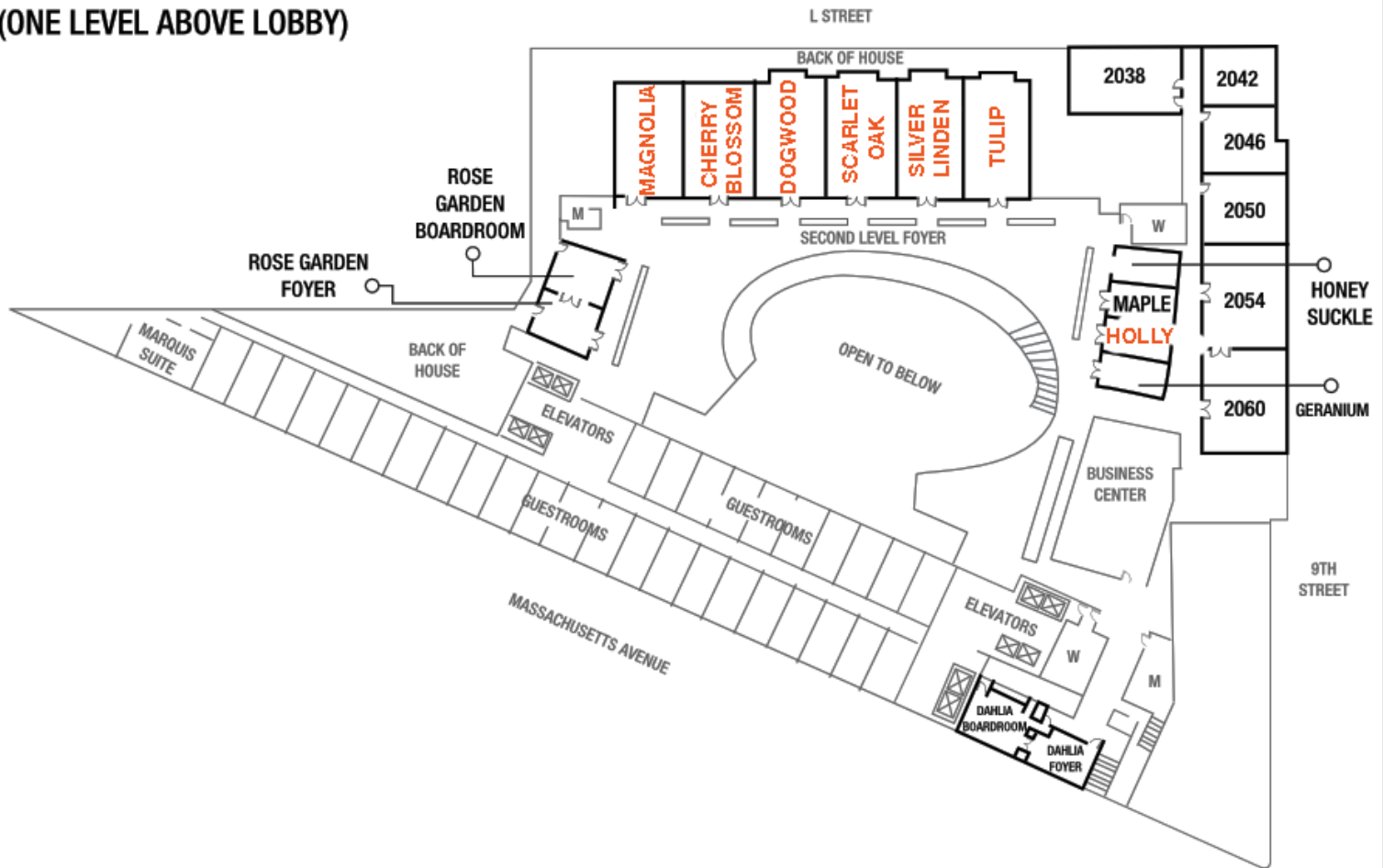


# Renaissance Hotel 2nd floor



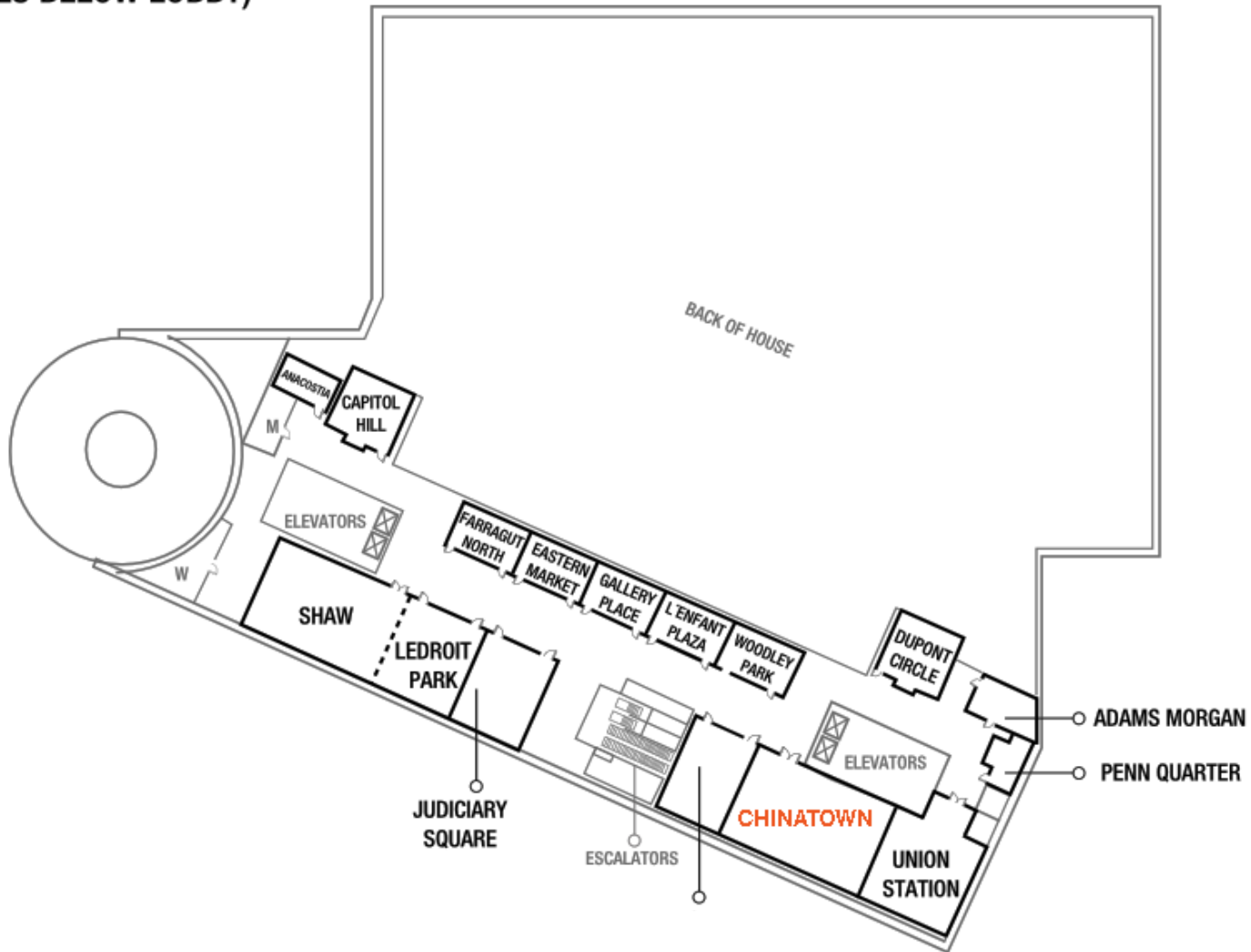
# Marriott Marquis meeting rooms

## 2ND FLOOR (ONE LEVEL ABOVE LOBBY)



# Marriott Marquis meeting rooms

**MEETING LEVEL 3 (M3)**  
**(THREE LEVELS BELOW LOBBY)**



# FOGGY BOTTOM

- THE VERN EXPRESS STOPS
- RESIDENCE HALLS
- HOTELS
- PARKING



**GW Admissions Welcome Center**  
 800 21st Street, NW  
 Marlin Center, First Floor  
 Washington, DC 20052

\* Medical Services, Mental Health Services, Health Promotion & Prevention Services and GW Parenting Initiative

## WORKSHOP BUILDINGS

### Science and Engineering Hall

800 22nd St., NW  
 Washington, DC 20052

### Corcoran Hall

725 21st St. NW  
 Washington, DC 20052



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THE GEORGE WASHINGTON UNIVERSITY

WASHINGTON, DC  
**AAPT** SUMMER MEETING  
 July 28-Aug. 1, Washington, DC  
PHYSICS EDUCATION

# Restaurants Near George Washington University

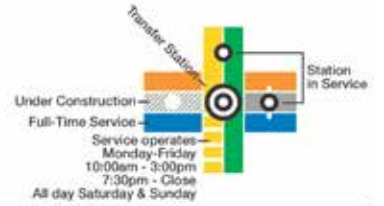
<b>Restaurant Name</b>	<b>Address</b>	<b>Type of Food</b>
Au Bon Pain	2000 Pennsylvania Ave NW	Sandwiches
&Pizza	2224 F St NW	Pizza
Baja Fresh	1990 K St NW	Mexican
Beefsteak	800 22nd St NW	Salad
Bertucci's	2000 Pennsylvania Ave NW	Italian
Bobby's Burger Palace	2121 K St NW	Burgers
Burger Tap and Shake	2200 Pennsylvania Ave NW	Burgers
Chick fil a 2	121 H St NW	Chicken
Chipotle	2000 Pennsylvania Ave NW #15	Mexican
Circa 2221	I St NW	Amerian
Devon & Blakely	2200 Pennsylvania Ave NW	Salads
GRK Fresh Greek	2121 H St NW	Greek
HomeSlyce	2121 K St NW	Pizza
Lindy's Bon Apetit	2040 I St NW	Pub Food
Magic Gourd	528 23rd St NW	Chinese
Panera 800	21st St NW	Sandwiches
Paul's 2000	Pennsylvania Ave NW	French
Perfect Pita	2000 Pennsylvania Ave NW	Pita
Poppabox	1928 I St NW	Asian
Potbelly Sandwiches	616 23rd St NW	Sandwiches
Roti 2221	I St NW	Mediterranean
Sol Mexican Grill	2121 H St NW	Mexican
Subway	2029 K St NW	Sandwiches
Sweetgreen	2221 I St NW	Salads
Tonic	2036 G St NW	American
TGI Friday's	2100 Pennsylvania Ave NW	American

# Metro System Map

wmata.com  
 Customer Information Service: 202-637-7000  
 TTY Phone: 202-962-2033  
 Metro Transit Police: 202-962-2121

- ### Legend
- Red Line • Glenmont / Shady Grove
  - Orange Line • New Carrollton / Vienna
  - Blue Line • Franconia-Springfield / Largo Town Center
  - Green Line • Branch Ave / Greenbelt
  - Yellow Line • Huntington / Mt Vernon Sq / Fort Totten
  - Silver Line • Wiehle-Reston East / Largo Town Center

- ### Station Features
- Bus to Airport
  - Parking
  - Hospital
  - Airport
- ### Connecting Rail Systems
- AMT
  - MARC



- No Smoking
- No Eating or Drinking
- No Animals (except service animals)
- No Audio (without earphones)
- No Littering or Spitting
- No Dangerous or Flammable Items