PURDUE INDUSTRIAL ENGINEERING I FALL 2012

IMPACT

GLOBAL CHALLENGES. ENGINEERING SOLUTIONS.

HOW PURDUE'S SCHOOL OF INDUSTRIAL ENGINEERING IS IMPACTING THE WORLD.

RETHINK IE

ON POSSIBILITIES

Welcome to *Industrial Engineering Impact*. Now is the perfect time for the Purdue School of Industrial Engineering (IE) to reach out to our alumni, industry partners, academic colleagues and friends.

The world, as we know, is evolving at a rate that most of us can hardly keep up with. Just look at what your cell phone can do — the services it provides are mind-boggling. The line between products and services has blurred to a point where we can no longer consider one without the other. It is also a world on information overload. Where we previously focused on squeezing maximum information out of sparse data, we now need to be able to connect the right dots in a sea of dots. And the ever-evolving technology is forcing us to not only rethink how we do business but also reinvent the very businesses themselves.

Purdue has played a critical role in the history of the industrial engineering profession. From fostering the development of computer simulation methodology to intelligent manufacturing, we have been revolutionizing IE all along. The grand challenges facing society today are forcing us to once again look for new ways. The time has come to "Rethink IE."

What role will future industrial engineers play in sustaining the environment, delivering cleaner energy and improving health care? How can we bring food and clean water to every corner of the world? Where do we fit into the changing needs of security and urban infrastructure?

At Purdue, we are already making headway. Key scientific advances in several critical areas are enabling us to address these problems. First, we are beginning to better understand the human brain. Reconciling normative, behavioral and neurophysiological bases of human decision-making will allow us to design effective socio-technical systems. Breakthroughs in bio- and nanosciences allow us to create structures one atom at a time. However, we need to scale up these processes — to go from atoms to devices to enterprises — in order to manufacture radically new products economically.

Photo by Mark Simons

Another game-changing opportunity is at the intersection of algorithms, data and networks. Where we once built algorithms optimized for a single processor, we will soon design algorithms that work on millions of processors simultaneously. And as industrial engineers, we are in an ideal place to tackle the grand challenges facing society by figuring out how it all fits together by leveraging our understanding of complex systems.

The stories to follow are a mere sampling of how we are "Rethinking IE" at Purdue.

By recharging energy, we are looking to harness nanotechnology to make green energy more affordable. Alumni have long been critical to our success. Cindy Niekamp (BSIE '81), who shares memories of helping to build the first Industrial Roundtable, is also helping to breathe new ideas into our school through her work on our advisory council. And we can only change the future of IE by overhauling our classrooms. As we readdress education, we're bringing students into real-time collaborations in the global business sphere, better training them for the profession that could change the world.

I encourage you to read these stories and share with me your thoughts on how you think we can better "Rethink IE."

Abhi Deshmukh

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FEATURES























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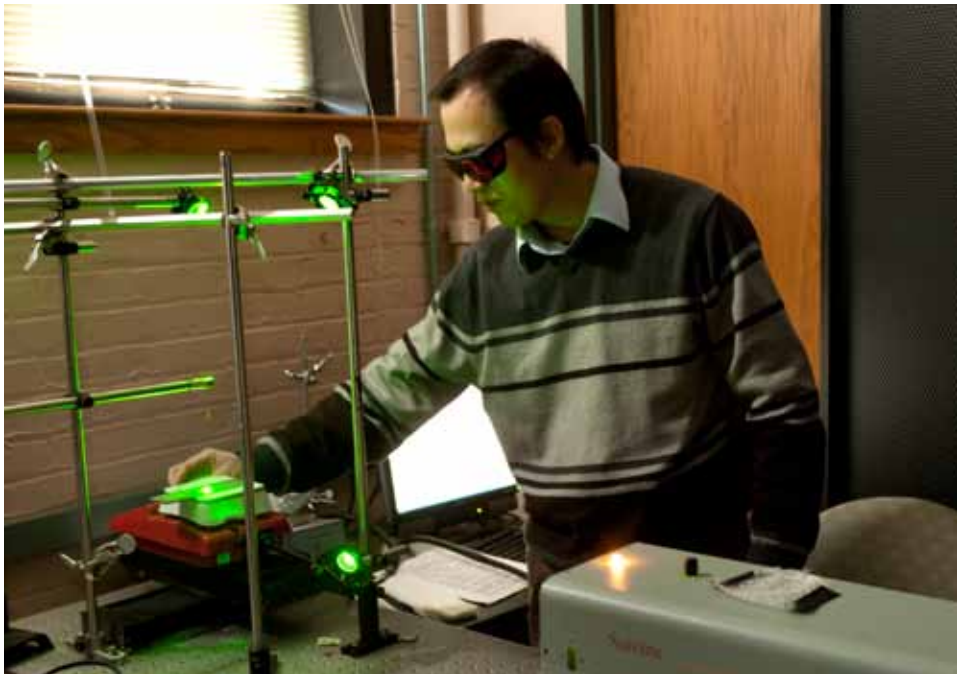
RISING TO THE CHALLENGE

Rethinking energy production and consumption

As energy demand and costs continue to grow, so too does the grand promise of green energy that uses sun, wind, water and other renewable power sources.

The grand challenge of making renewable energy a reality, however, hinges on making such advances less costly, efficient and economically viable — goals at the heart of Purdue's School of Industrial Engineering, which has a legacy of helping those who make things do it better, faster, safer and cheaper.

Today, that expertise is being used by researchers at the school to improve the world's ability to produce, distribute and use environmentally sustainable energy and energy devices on scales both small and large — from nanowires and biomaterials to solar panels and smart grids.



Gary Cheng, associate professor of industrial engineering, uses a new method called laser shock-induced shaping to tune nanowires. (Photo by Mark Simons)

NANO-MACHINE SHOPS

Gary Cheng, associate professor of industrial engineering, and C. Richard Liu, professor of industrial engineering and director of global programs, are applying nanotechnology to manufacturing of energy devices.

Under their guidance, doctoral students are developing a new manufacturing method that shapes nanowires and ultrathin films into structures that might be used for applications ranging from high-speed electronics to solar cells. The greater strength and unusual traits of these structures, such as "plasmonic resonance" and ultrahigh magnetism, could also lead to improved optics, computers and electronics.

The researchers use their technique to stamp nano- and microgears; form tiny circular shapes out of a material called graphene, an ultrathin sheet of carbon that holds promise for advanced technologies; and change the shape of silver nanowires. "We do this shaping at room temperature and atmospheric pressure, like a nano-machine shop," Cheng says.

Graphene and nanowires — filaments 1,000 times thinner than a human hair — have numerous potential applications. However, technologies are needed to tailor them for specific uses. The new method, called laser shock-induced shaping, makes it possible to tune nanowires by altering electrical and optoelectrical properties that are critical for electronic components.

The researchers also have shown how laser shock-induced shaping can be used to change the properties of graphene, a step toward harnessing the material for electronic applications. The process could be scaled up for an industrial roll-to-roll manufacturing process by changing laser beam size and scanning speed, making it fast and economical.

Purdue researchers are also using high-speed lasers to modify thin-film solar panels and improve the absorption of sunlight, which is the key to improved energy production. The method being devised at Purdue will make solar panels more affordable for industry and consumers alike.

This illustration depicts a new nano machine shop's ability to shape tiny wires, an advance that represents a possible future manufacturing method for applications ranging from high-speed electronics to solar cells. (Purdue University image/Gary Cheng)

GETTING SMART

The grand challenges and promises of advances in materials and manufacturing are equaled on another scale by macro-level obstacles in how energy and its production are managed, measured, sold and bought.

Liu is addressing those larger issues in student-supported research initiatives focused on the implementation of smart-grid technology to transform the current electricity grid into modern and sustainable electricity systems.

"Future U.S. economic growth and societal needs require a secure, reliable and sustainable electric grid that can incorporate new technologies in renewable energy generation, energy storage, demand-side management and electric vehicles," Liu says. "Yet the nation's current grid infrastructure, mainly built between the 1930s and 1980s, is overstressed to accommodate these innovations."

Efforts to modernize the aging infrastructure have given rise to the notion of smart grid technology that makes the system more robust and resilient, accommodates all options for energy generation and storage and enables the active participation of consumers.

Making such a system actually work, Liu says, is a different challenge altogether. "Without a detailed, integrated market and system design that coordinates and secures where electricity is generated, delivered and priced, the promised benefits of the next-generation grid cannot be realized."

Pilot projects in the U.S. and Europe using an advanced metering infrastructure and dynamic retail electricity rates to induce behavior change and lower consumers' electric consumption have resulted in only modest savings, Liu says. They also revealed a vulnerability to attacks on both the physical and cyber systems of electricity grids.

To bridge these gaps, Liu and his co-researchers are working toward a solution that links the cyber and physical aspects of such systems and synchronizes the information processing and physical electricity flow with real-time prices of electricity.

It's an ambitious, interdisciplinary solution at the intersection of power-system engineering, operations research, computer science, economics, consumer science and electrical engineering technologies, Liu says.

"The ultimate goal is to use our research as the backbone of a secure and robust power grid and a fair, real-time pricing market design that support consumer participation, energy management and new technologies," Liu says. "This system should fully integrate bulk electricity generation and transmission macro-grids with automated, distributed generation and energy storage micro-grids."

A big idea, yes, but one of no small importance in a world that continues to demand better and more.

■ **BY ERIC NELSON AND EMIL VENERE**

Cindy Niekamp (BSIE '81) on campus with her daughter, Elizabeth, a Purdue freshman. (Photo by Mark Simons)

ADAPTATION

Alumna makes right moves throughout engineering career

> "PURDUE HAS A RICH HISTORY IN INDUSTRIAL ENGINEERING. BUT THE NEED TO ADAPT TO CHANGING TIMES IS AS CRITICAL AS EVER."
>
> — CINDY NIEKAMP

In mid-August, when Cindy Niekamp (BSIE '81) dropped off her youngest daughter, Elizabeth, for Boiler Gold Rush (the weeklong orientation for incoming freshmen), her family became one of Purdue's many multigenerational families. The return to campus is not unusual for Niekamp. She's been part of the Industrial Engineering Advisory Board for almost five years. And she admits to feeling a certain debt to Purdue for the education she received.

Now the senior vice president, automotive coatings at PPG Industries, a $2.5 billion business that sells to the leading car manufacturers around the world, Niekamp went to Harvard Business School shortly after her Purdue days. "Purdue and the School of Industrial Engineering (IE) gave me the technical and problem-solving skills to be able to think through challenges in a logical way," she says. "I had always been interested in math, but I really honed in on the quantitative skills I acquired here."

Outside of academics, Niekamp also developed leadership skills at Purdue. Involvement in the Delta Gamma sorority, Mortar

Board and an attempt to rebuild the then-recently defunct Purdue Engineering Student Council (PESC) prepped her for the challenges of a forthcoming career. With only $50 in the PESC account, some fundraising was in order. Niekamp volunteered to be the student representative for IE.

One initiative led to the formation of the Industrial Roundtable (see sidebar), now the largest student-run job fair in the country. "We had this idea of getting companies on campus to connect with students," Niekamp says. "It took some real convincing to get the folks in Career Services to give us the company addresses. And we made a lot of mistakes. This was before email, so we sent all of these letters, but had probably close to 200 companies show up."

THE DANCE OF INDUSTRIAL ENGINEERING

Whether she was looking to go to school a little farther away from her home in Ohio, or maneuvering a career path where she was often the only female engineer in the room, Niekamp has made a history of adapting to change. Around 1976, she came to a Purdue engineering summer camp for young women and stayed in a residence hall. "They held this dance and I was just thrilled that boys asked girls to dance here," she says.

She has since choreographed a career that's run the corporate ladder through senior leadership positions at manufacturing giants such as General Motors, TRW, MeadWestvaco and BorgWarner. Today, at PPG, she manages some 5,000 employees at 18 worldwide plants.

But the need to adapt to changing times is as critical as ever, says Niekamp, who received an Outstanding Industrial Engineer Award in 1998 and was named one of Purdue's Distinguished Engineers in 2005. "When I graduated from Purdue, industrial engineering had a manufacturing and operational systems focus. Since then, the service part of our economy has grown so much."

She's concerned about the tendency in corporate America to silo people and functions. "The ability to interconnect cross-functional, interdisciplinary aspects is huge in the global, increasingly complex corporate world," Niekamp says. "I think that's where industrial engineers can play a critical role."

To that end, and perhaps helping to reshape an industrial engineering education that could revolutionize the industry, she has worked with a diverse group of alumni on the advisory board to help the school explore a new vision. "We are in the process of regaining our national and international leadership position," says Niekamp, who also has endowed a scholarship in the school. "Purdue has rich history in industrial engineering. And it is exciting to know that we are refreshing that."

■ WILLIAM MEINERS

(Photo by Steven Yang)

ROUNDTABLE REVOLUTION

What began as an almost surprisingly successful event for a then-fledgling Purdue Engineering Student Council (PESC) in the early 1980s has become the largest student run job fair in the country today. And the Industrial Roundtable (IR) seems to be paying dividends for student organizers and job searchers, as well as the companies seeking to hire them.

Karen Rockwell, a sophomore in industrial engineering, joined PESC in spring 2012 and quickly contributed as a member of the IR Committee. Her role has been twofold: to organize a scholarship for students and help ensure a successful experience for students attending the job fair. "As I helped recruit companies to the job fair, I also asked them to contribute to a scholarship fund," Rockwell says.

It looks to be a job well done. This year s IR was its largest in history with more than 360 companies in attendance. She also organized a student tent to help settle the nerves of young job searchers. Students were able to drop off backpacks, check on appearances, grab a drink of water and even run their introductions by representatives of Purdue s Center for Career Opportunities.

Industrial engineering students have a wide range of opportunities at the roundtable. Companies, large and small, from health care to aerospace and food to transportation industries are looking for the particular expertise of industrial engineering thinkers.

For Rockwell, some 30 years after Cindy Niekamp began gaining confi dence in her own leadership abilities, the IR experience is simply round ing out her education. "Working on a major event like the largest student run job fair in the nation has helped me sharpen my industrial engineering thought process," Rockwell says. "There is no time to redo processes in planning it, and I've learned how to best execute plans efficiently and quickly to produce optimal results.

■ WILLIAM MEINERS

CLASSROOM EVOLUTION

Collaboration at the core of IE curriculum

Just as the profession of industrial engineering changes, so must the ways in which students are educated. Graduates must not only have strong technical skills but also an understanding of the human and social dimensions of their decisions in order to attack the grand challenges facing the world. The global marketplace demands real-time collaboration with multi-cultural teams dispersed throughout the world.

Abhi Deshmukh, the James J. Solberg Head of Industrial Engineering, says the school is creating opportunities for students to learn skills beyond the classroom to be successful in their careers. "Leadership, collaboration, global perspective, entrepreneurship and ethics — all of these added dimensions are creating a new kind of industrial engineer," he says.

Just as the world is evolving at a rapid pace, the School of Industrial Engineering (IE) is rethinking how it trains students to be successful engineers and leaders.

TRAINING THE ENGINEER OF 2020

Barrett Caldwell, professor of industrial engineering, focuses on including the human element in systems education. As a student, he dreamed of working in the space program after hearing Apollo 8 astronaut Frank Borman speak from lunar orbit. As an engineer, he became increasingly disconcerted when talking with other engineers who didn't want to think about the psychological or social factors influencing astronauts on long-duration missions, he says.

"As a systems engineer, you can't simply ignore a critical component of your system and refuse to learn anything about that component's behavior," Caldwell says. "So I continued my training in psychology to be a systems engineer for whom humans were my subsystem area of expertise."

In addition to understanding how humans integrate with the systems of the future, the IE of 2020 will need to collaborate with other humans on multidisciplinary teams to create solutions. That concept is what drives IE education through the IE senior design course, the Collaboratorium, HUB-CI (Collaborative Intelligence) and the PRISM (Production, Robotics and Integration Software for Manufacturing and Management) Center.

IE's senior design course has students working in teams to resolve design and operational issues for companies. These companies vary from parts manufacturing to continuous process production to health care providers and other forms of service. Students are exposed to the way real companies operate, and the companies discover how industrial engineering methods can help their operations and bottom line.

The Collaboratorium is a teaching laboratory in Grissom Hall (the home of IE) specifically constructed to support these senior design projects. It provides a unique space for students in the design class to have interaction with customers and partners, both physically in the room and digitally worldwide.

Caldwell says learning there can be done anytime. "They can do videoconference conversations and record videos for their customers at 8 in the morning or 8 at night."

Past versions of the senior design projects were limited to locations within a reasonable drive to campus. Now, through the Collaboratorium, students can interact with companies and organizations anywhere to expand opportunities for projects in their area of interest.

"I can walk down the hall and see a team working on a senior design project on one of the shared screens," Caldwell says. "I can stop in, hear what they're doing and give them a hint or piece of advice. That 10-minute interaction can be worth more than a week of scheduled class because it ties directly with what that team is doing while they're working on the problem." It also provides closer connection to faculty.

HUB-CI, an extension of Purdue's HUBzero computer platform,

makes it easy for project teams to share analytical results and create consensus while interacting with their clients in real time through the Internet. It is one of the tools used for collaboration, analysis and presentation by Purdue students.

Mark Lehto, professor and director of industrial engineering's Discovery-to-Delivery Center, says HUB-CI has greatly enhanced the senior design class. HUB-CI technology allows clients and students from around the world to monitor the work being done on the project and to make comments and suggestions.

Lehto says it provides a benefit for IE students and partner companies in learning from each other. "Instead of waiting a couple of weeks after the students have done their presentations to access information, our partner companies are able to access it immediately," Lehto says. "During the presentation, the client is able to see streaming video, the final reports and all of the different projects' analysis."

GLOBAL PARTNERSHIPS ENRICH LEARNING

Shimon Nof, professor of industrial engineering and director of PRISM, says center researchers have partnered with other researchers around the globe to improve efficiencies for companies.

"We developed the theory and support systems for collaborations with industries and research centers over the past 15 years," he says. One of those collaborations has been with Kimberly-Clark Corp. in its Latin American operations thanks to Juan Ernesto de Bedout (BSIE '67, MSIE '68), retired group president, who chairs the College of Engineering's Advisory Council.

HUB-CI enables students, researchers and companies to view the work each team is doing, monitor progress and discuss projects in real time. The outcome is a virtual laboratory where students and industrial engineering clients can come together.

The Purdue HUB infrastructure provides unique features that keep those shared interactions private and secure, just for those team members and partners who share the project.

One of the advantages of the HUB infrastructure is "tool networking," where students and researchers can apply the best available simulation tools. These tools are made available both to researchers and to senior design class participants.

"We are introducing and experimenting with these as part of the college's strategic action called Cyber Reach and in collaboration with Purdue's information technology office," Nof says. "Other engineering senior design projects also will benefit from the HUB-CI in the near future."

An example is a tool developed in the PRISM Center that enables students to be matched better — based on their skills, experience and interests — with other students and company partners at the beginning of the semester. The tool will be applied throughout the semester to match teams with overlapping problems and solutions.

"All of these practices are evolving the design project team experience from the traditional ways to the competitive, agile and collaborative work methods of the future," Nof says.

Students learn computational competencies beyond information and data sharing that will be practiced in the industry of 2020, Nof says. They also learn how to work with and leverage cyber-based collaboration and design-tool sharing.

"Until we have industrial, service or educational systems that don't have any humans in them anywhere — or systems that don't care about cost and efficiency," Caldwell says,"this ability to integrate the range of IE tools and techniques to solve problems will continue to be relevant to fill educational, professional and societal needs."

■ **DELLA PACHECO**

The Collaboratorium (Grissom 210) provides more space for students in the design class to have interaction with customers and partners, both physically in the room and digitally worldwide. (Photos by Mark Simons)

IN THE NEWS

Following are a few highlights from the School of Industrial Engineering (IE) over the last year. An institute's tribute to a legendary professor. The developmental efforts to enhance the School of Industrial Engineering. The record-breaking success of our students. All have helped in Rethinking IE. For the latest news, visit us online at **www.purdue.edu/IE.**

INSTITUTE OF INDUSTRIAL ENGINEERS RENAMES STUDENT AWARD FOR JAMES BARANY

James W. Barany (MSIE '56, PhD '61), who died in November 2011, spent more than half a century at Purdue, becoming a much beloved figure to students within the School of Industrial Engineering. The award-winning professor and advisor had affection for students that extended long beyond their graduation.

Not surprising then that his legacy of student commitment will now continue thanks to the Institute of Industrial Engineers (IIE), which has renamed its Student Award for Excellence the "James W. Barany Student Award for Excellence." The award, which recognizes student scholarship and campus leadership, specifically singles out students who have brought distinction to industrial engineering at their respective schools. It will be presented each year at the IIE's annual conference.

MEET LARRY SOMMERS: IE'S NEW DIRECTOR OF DEVELOPMENT

A 15-year veteran of Purdue, Larry Sommers joined the School of Industrial Engineering staff in June as the new director of development. He most recently served in development positions for the John Purdue Club, Housing and Food Services and Mechanical Engineering. As director of development, Sommers heads fundraising and alumni relations for the school.

IE alums who would like to update their contact information, or who have any questions about making a gift of any kind to the school, should contact Sommers at 765-496-6192 or lsommers@purdue.edu.

3 SUSTAINING IMPACT/STRATEGIC INITIATIVE ENDOWMENTS CREATED TO SUPPORT PURDUE IE

In October 2011, Purdue's College of Engineering launched a matching-gift opportunity made possible by funds allocated to supplement donor investments in strategic initiatives. The Sustaining Impact/Strategic Initiative program called for the college to provide a 100 percent match for new endowments created to support named sustaining impact/strategic initiatives within the schools, giving donors the opportunity to help shape the future of the school or program of their choice.

Juan Ernesto de Bedout (BSIE '67, MSIE '68), Steve McGaw (BSIE '84) and Professor Emeritus Dale Compton each took this opportunity to make a generous investment in the future of the school and created endowments that will provide unrestricted funds for Purdue IE into perpetuity. The School of Industrial Engineering is very grateful for these important gifts.

The Purdue Society of Professional Engineers team poses with its world record-setting Rube Goldberg machine. The team spent more than 5,000 total hours building the 300-step contraption, which flawlessly inflated and popped a balloon. (Photo provided by Andy Jessop)

GUINNESS CROWNS PURDUE RUBE GOLDBERG MACHINE 'WORLD'S LARGEST'

In April, Guinness World Records designated a 300-step Rube Goldberg machine built by Purdue students as the largest in the world.

School of Industrial Engineering students Carlos Hinojosa, Mayank Garg and Javier Garcia, along with their colleagues from the Purdue Society of Professional Engineers and the Hispanic Society of Professional Engineers, invested more than 5,000 total hours to build the innovative behemoth, which performed the assigned task of inflating and popping a balloon at this year's Rube Goldberg Machine Contest intercollegiate national championship.

The machine has become an Internet sensation, scoring nearly 1 million YouTube views and coverage from a host of online media including MSNBC, *Forbes*, *Popular Mechanics*, *Wired*, Huffington Post, *PC Magazine*, Yahoo, Big Ten Network, Discovery Canada and cnet.com.

Purdue's machine accomplished every task ever assigned in the competition's 25-year history, including peeling an apple, juicing an orange, toasting bread, making a hamburger, changing a light bulb, loading a CD, crushing a can and sharpening a pencil. Stephen Colbert, Guy Kawasaki and Penn Jillette have all commented on the machine.

In a nod to Purdue's Boilermaker mascot, the team powered portions of the machine with a homemade boiler system boasting an elaborate locomotive-like drive system that inflated the balloon. The team claimed the People's Choice Award and a prize for the most "Rube-ish" step, which used an accordion arm that sprung free to pop the balloon.

"We did some bold things with this machine that have never even been attempted," says team president Zach Umperovitch. "We don't set out to break records, but we always aim to push the envelope of what is possible."

■ **JIM SCHENKE**

To watch the YouTube video of the record-breaking machine, scan this QR code.

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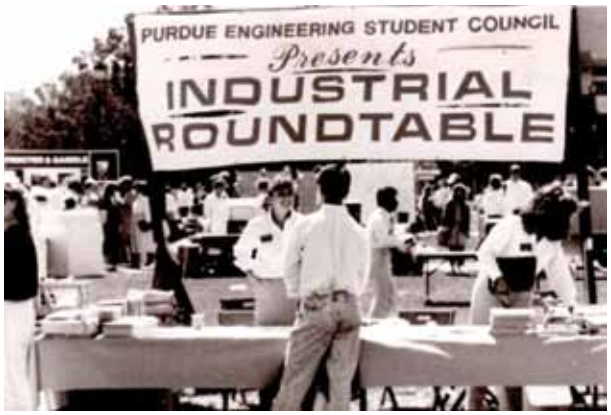

INDUSTRIOUS JOB SEEKERS

Now the largest student run job fair in the nation, Purdue s Industrial Roundtable got its start in the 1980s with a little help from some ambitious students from the School of Industrial Engineering. Specifically Cindy Niekamp (BSIE '81), whose story is on page 4.