Active Learning

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What is it?

In their seminal work *Active Learning: Creating Excitement in the Classroom*, compiled in 1991 for the Association for the Study of Higher Education and the ERIC Clearinghouse on Higher Education, Bonwell and Eison defined strategies that promote active learning as "instructional activities involving students in doing things and thinking about what they are doing" (Bonwell and Eison, 1991). Approaches that promote active learning focus more on developing students' skills than on transmitting information and require that students do something—read, discuss, write—that requires higher-order thinking. They also tend to place some emphasis on students' explorations of their own attitudes and values.

This definition is broad, and Bonwell and Eison explicitly recognize that a range of activities can fall within it. They suggest a spectrum of activities to promote active learning, ranging from very simple (e.g., pausing lecture to allow students to clarify and organize their ideas by discussing with neighbors) to more complex (e.g., using case studies as a focal point for decision-making). In their book *Scientific Teaching*, Handelsman, Miller and Pfund also note that the line between active learning and formative assessment is blurry and hard to define; after all, teaching that promotes students' active learning asks students to do or produce something, which then can serve to help assess understanding (2007).

"Instructional activities involving students in doing things and thinking about what they are doing."
Bonwell and Eison, 1991

"Active learning implies that students are engaged in their own learning. Active teaching strategies have students do something other than taking notes or following directions… they participate in activities… [to] construct new knowledge and build new scientific skills."
Handelsman et al., 2007

"Active learning engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work."
Freeman et al., 2014

"Students' efforts to actively construct their knowledge."
Carr et al., 2015

The National Survey of Student Engagement (NSSE) and the Australasian Survey of Student Engagement (AUSSE) provides a very simple definition: active learning involves "students' efforts to actively construct their knowledge." This definition is supplemented by the items that the AUSSE uses to measure active learning: working with other students on projects during class; making a presentation; asking questions or contributing to discussions; participating in a community-based project as part of a course; working with other students outside of class on assignments; discussing ideas from a course with others outside of class; tutoring peers (reported in Carr et al., 2015).

Freeman and colleagues collected written definitions of active learning from >300 people attending seminars on active learning, arriving at a consensus definition that emphasizes students' use of higher order thinking to complete activities or participate in discussion in class (Freeman et al., 2014). Their definition also notes the frequent link between active learning and working in groups.

Thus active learning is commonly defined as **activities that students do to construct knowledge and understanding.** The activities vary but require students to do **higher order thinking**. Although not always explicitly noted, **metacognition**—students' thinking about their own learning—is an important element, providing the **link between activity and learning**.

What's the theoretical basis?

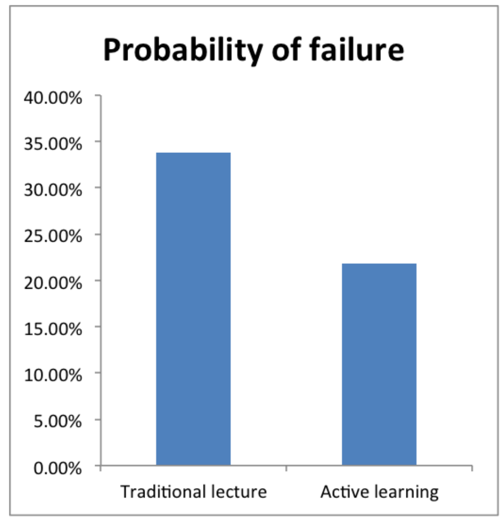
Constructivist learning theory emphasizes that individuals learn through building their own knowledge, connecting new ideas and experiences to existing knowledge and experiences to form new or enhanced understanding (Bransford et al., 1999). The theory, developed by Piaget and others, posits that learners can either assimilate new information into an existing framework, or can modify that framework to accommodate new information that contradicts prior understanding. Approaches that promote active learning often explicitly ask students to make connections between new information and their current mental models, extending their understanding. In other cases, teachers may design learning activities that allow students to confront misconceptions, helping students reconstruct their mental models based on more accurate understanding. In either case, approaches that promote active learning promote the kind of cognitive work identified as necessary for learning by constructivist learning theory.

Active learning approaches also often embrace the use of cooperative learning groups, a constructivist-based practice that places particular emphasis on the contribution that social interaction can make. Lev Vygotsky's work elucidated the relationship between cognitive processes and social activities and led to the sociocultural theory of development, which suggests that learning takes place when students solve problems beyond their current developmental level with the support of their instructor or their peers (Vygotsky 1978). Thus active learning approaches that rely on group work rest on this sociocultural branch of constructivist learning theory, leveraging peer-peer interaction to promote students' development of extended and accurate mental models.

Is there evidence that it works?

The evidence that active learning approaches help students learn more effectively than transmissionist approaches in which instructors rely on "teaching by telling" is robust and stretches back more than thirty years (see, for example, Bonwell and Eison, 1991). Here, we will focus on two reports that review and analyze multiple active learning studies.

Freeman and colleagues conducted a meta-analysis of 225 studies comparing "constructivist versus exposition-centered course designs" in STEM disciplines (Freeman et al., 2014). They included studies that examined the design of class sessions (as opposed to out-of-class work or laboratories) with at least some active learning versus traditional lecturing, comparing failure rates and student scores on examinations, concept inventories, or other assessments. They found that students in traditional lectures were 1.5 times more likely to fail than students in courses with active learning (odds ratio of 1.95, Z = 10.4, P<<0.001). Further, they found that on average, student performance on exams, concept inventories, or other assessments increased by about half a standard deviation when some active learning was included in course design (weighted standardized mean difference of 0.47, Z = 9.781, P<<0.001). These results were consistent across disciplines: they observed no significant difference in the effects of active learning in biology, chemistry, computer science, engineering, geology, math, physics, and psychology courses. They performed two analyses examining the possibility that the results were due to a publication bias (i.e., a bias toward publishing studies with larger effects), finding that there would have to be a large number of unpublished studies that observed no difference between active learning and lecturing to negate their findings: 114 reporting no difference on exam or concept inventory performance and 438 reporting no difference in failure rate. The authors conclude that the evidence for the benefits of active learning are very strong, stating that, "If the experiments analyzed here had been conducted as randomized controlled trials of medical interventions, they may have been stopped for benefit—meaning that enrolling patients in the control condition might be discontinued because the treatment being tested was clearly more beneficial."



These results support other, earlier reviews (e.g., Hake, 1998; Prince, 2004; Springer et al., 1999). In one such review, Ruiz-Primo and colleagues examined published studies examining the effects of active learning approaches in undergraduate biology, chemistry, engineering and physics courses (Ruiz-Primo et al., 2011). They identified 166 studies that reported an effect size when comparing the effects of an innovation (i.e., active learning approaches) to traditional instruction that did not include the innovation. Overall, they found that inclusion of the active learning approaches improved student outcomes (mean effect size = 0.47), although there are important caveats to consider. First, the authors coded the active learning activities as conceptually oriented tasks, collaborative learning activities, technology-enabled activities, inquiry-based projects, or some combination of those four categories, and important differences existed within the categories (for example, technology-assisted inquiry-based projects on average did not produce positive effects). Second, more than 80% of the studies included were quasi-experimental rather than experimental, and the positive benefits (average effect size = 0.26) were lower for the experimental studies in which students were randomly assigned to a treatment group. Finally, many of the studies did not control for pre-existing knowledge and abilities in the treatment groups. Nonetheless, the review does provide qualified support for the inclusion of active learning approaches in instruction.

While the two reviews reported focus on STEM disciplines and no similar reviews exist for the humanities and social sciences, the bulk of the evidence suggests that active learning approaches are effective across disciplines (Ambrose et al, 2010; Bonwell and Eison, 1991; Chickering and Gamson, 1987).

Why is it important?

In addition to the evidence that active learning approaches promote learning for all students, there is some evidence that active learning approaches are an effective tool in making classrooms more inclusive. Haak and colleagues examined the effects of active learning for students in the University of Washington's Educational Opportunity Program (EOP) who were enrolled in an introductory biology course (Haak et al., 2011). Students in the EOP are educationally or economically disadvantaged, are typically the first in their families to attend college, and include most underrepresented minority students at the University of Washington. Previous work had demonstrated that the researchers could predict student grades in the introductory biology course based on their college GPA and SAT verbal score; students in the EOP had a mean failure rate of ~22% compared to a mean failure rate of ~10% for students not in the EOP. When multiple highly structured approaches to promote active learning were incorporated into the introductory biology course, all students in the course benefited, but students in the EOP demonstrated a disproportionate benefit, reducing the achievement gap to almost half of the starting level. Given the pressing need to make U.S. college classrooms more inviting and productive spaces for students from all backgrounds, these results provide another compelling reason to incorporate active learning approaches into course design.

Lorenzo, Crouch, and Mazur also investigated the impact of active learning approaches on the difference in male and female performance in introductory physics classes (2006). They found that inclusion of active engagement techniques benefited all students, but had the greatest impact on female students' performance. In fact, when they included a "high dose" of active learning approaches, the gender gap was eliminated. This result supports earlier work suggesting that women particularly benefit from active learning approaches (Laws et al., 1999; Schneider, 2001).

What are techniques to use?

Brief, easy supplements for lectures

The Pause Procedure— Pause for two minutes every 12 to 18 minutes, encouraging students to discuss and rework notes in pairs. This approach encourages students to consider their understanding of the lecture material, including its organization. It also provides an opportunity for questioning and clarification and has been shown to significantly increase learning when compared to lectures without the pauses. (Bonwell and Eison, 1991; Rowe, 1980; 1986; Ruhl, Hughes, & Schloss, 1980)

Retrieval practice—Pause for two or three minutes every 15 minutes, having students write everything they can remember from preceding class segment. Encourage questions. This approach prompts students to retrieve information from memory, which improves long term memory, ability to learn subsequent material, and ability to translate information to new domains. (Brame and Biel, 2015; see also the CFT's guide to test-enhanced learning)

Demonstrations—Ask students to predict the result of a demonstration, briefly discussing with a neighbor. After demonstration, ask them to discuss the observed result and how it may have differed from their prediction; follow up with instructor explanation. This approach asks students to test their understanding of a system by predicting an outcome. If their prediction is incorrect, it helps them see the misconception and thus prompts them to restructure their mental model.

Think-pair-share—Ask students a question that requires higher order thinking (e.g., application, analysis, or evaluation levels within Bloom's taxonomy). Ask students to think or write about an answer for one minute, then turn to a peer to discuss their responses for two minutes. Ask groups to share responses and follow up with instructor explanation. By asking students to explain their answer to a neighbor and to critically consider their neighbor's responses, this approach helps students articulate newly formed mental connections.

Peer instruction with ConcepTests—This modification of the think-pair-share involves personal response devices (e.g., clickers). Pose a conceptually based multiple-choice question. Ask students tothink about their answer and vote on a response before turning to a neighbor to discuss. Encourage students to change their answers after discussion, if appropriate, and share class results by revealing a graph of student responses. Use the graph as a stimulus for class discussion. This approach is particularly well-adapted for large classes and can be facilitated with a variety of tools (e.g., Poll Everywhere, TopHat, TurningPoint). More information is available in the CIRTL MOOC *An Introduction to Evidence-Based College STEM Teaching*. *(Fagen et al., 2002; Crouch and Mazur, 2001)*

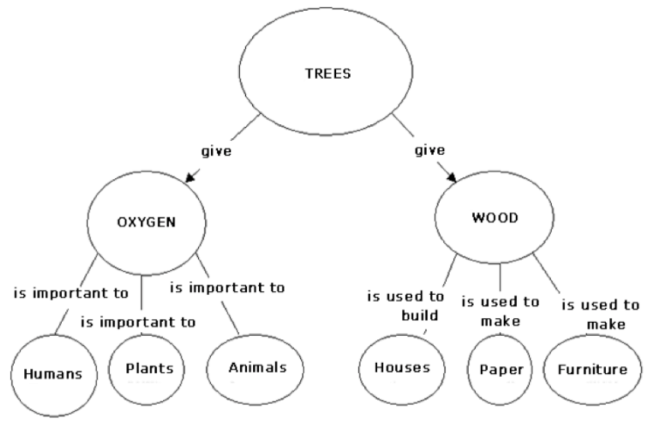
Minute papers—Ask students a question that requires them to reflect on their learning or to engage in critical thinking. Have them write for one minute. Ask students to share responses to stimulate discussion or collect all responses to inform future class sessions. Like the think-pair-share approach, this approach encourages students to articulate and examine newly formed connections. (Angelo and Cross, 1993; Handelsman et al., 2007)

Activities to replace some lecture

Strip sequence—Give students the steps in a process on strips of paper that are jumbled; ask them to work together to reconstruct the proper sequence. This approach can strengthen students' logical thinking processes and test their mental model of a process. (Handelsman et al., 2007) An example from Aarhus University is provided at right.

Example strip sequence from Aarhus University *Organize the following events that occur during respiration in the correct order. Specify on your final sequence the names of the major steps to which these events correspond. If an event does not occur during respiration, eliminate it.*
O_2 is reduced to H_2O.
Polymers are digested into monomers.
The oxygen atom of H_2O is lost as waste in CO_2.
A lot of ATP molecules are made.
CO_2 is released as a waste product during oxidation of pyruvate.
Protons go from the intermembrane space to the matrix.
Pyruvate is transported into the mitochondrion.
NADH gives away its electrons and a proton gradient is created.
ATP molecules are formed in the cytosol and NAD^+ is reduced.

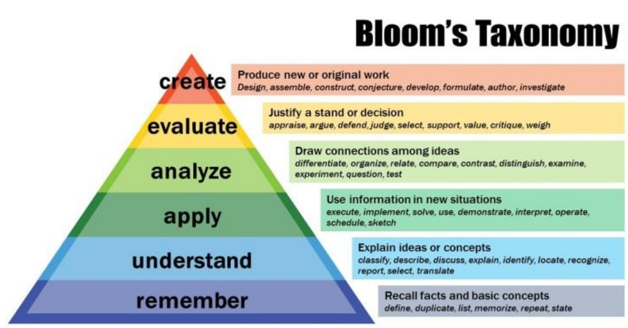
Concept map—Concept maps are visual representations of the relationships between concepts. Concepts are placed in nodes (often, circles), and the relationships between indicated by labeled arrows connecting the concepts. To have students create a concept map, identify the key concepts to be mapped in small groups or as a whole class. Ask students to determine the general relationship between the concepts and to arrange them two at a time, drawing arrows between related concepts and labeling with a short phrase to describe the relationship. By asking students to build an external representation of their mental model of a process, this approach helps students examine and strengthen the organization within the model. Further, it can emphasize the possibility of multiple "right" answers. More information and a tool to do online concept mapping can be found at the Institute for Human & Machine Cognition. (Novak and Canas, 2008) An example is shown at right.



Mini-maps. Mini-maps are like concept maps, but students are given a relatively short list of terms (usually 10 or fewer) to incorporate into their map. To use this approach, provide students a list of major concepts or specific terms and ask them to work in groups of two or three to arrange the terms in a logical structure, showing relationships with arrows and words.   Ask groups to volunteer to share their mini-maps and clarify any confusing points. Mini-maps have many of the same strengths as concept maps but can be completed more quickly and thus can serve as part of a larger class session with other learning activities. (Handelsman et al., 2007)

Categorizing grids. Present students with a grid made up of several important categories and a list of scrambled terms, images, equations, or other items. Ask students to quickly sort the terms into the correct categories in the grid. Ask volunteers to share their grids and answer questions that arise. This approach allows students to express and thus interrogate the distinctions they see within a field of related items. It can be particularly effective at helping instructors identify misconceptions. (Angelo and Cross, 1993)

Student-generated test questions. Provide students with a copy of your learning goals for a particular unit and a figure summarizing Bloom's taxonomy (with representative verbs associated with each category). Challenge groups of students to create test questions corresponding to your learning goals and different levels of the taxonomy. Consider having each group share their favorite test question with the whole class or consider distributing all student-generated questions to the class as a study guide. This approach helps students consider what they know as well as implications of the instructor's stated learning goals. (Angelo and Cross, 1993)



Content, form, and function outlines. Students in small groups are asked to carefully analyze a particular artifact—such as a poem, a story, an essay, a billboard, an image, or a graph—and identify the "what" (the content), the "how" (the form), and the function (the why). This technique can help students consider the various ways that meaning is communicated in different genres. (Angelo and Cross, 1993)

Decision-making activities. Ask students to imagine that they are policy-makers who must make and justify tough decisions. Provide a short description of a thorny problem, ask them to work in groups to arrive at a decision, and then have groups share out their decisions and explain their reasoning. This highly engaging technique helps students critically consider a challenging problem and encourages them to be creative in considering solutions. The "real-world" nature of the problems can provide incentive for students to dig deeply into the problems. (Handelsman et al., 2007)

Example for a biology class
(from Handelsman et al., 2007)

You are the head of a major blood bank, and there is a worldwide blood shortage. You are offered a shipment of blood that might be contaminated with a new retrovirus that has not been well studied. Will you allow the blood to be used? Why? What would you like to know before you make your decision?

Case-based learning. Much like decision-making activities, case-based learning presents students with situations from the larger world that require students to apply their knowledge to reach a conclusion about an open-ended situation. Provide students with a case, asking them to decide what they know that is relevant to the case, what other information they may need, and what impact their decisions may have, considering the broader implications of their decisions. Give small groups (3-5) of students time to consider responses, circulating to ask questions and provide help as needed. Provide opportunities for groups to share responses; the greatest value from case-based learning comes from the complexity and variety of answers that may be generated. More information and collections of cases are available at the National Center for Case Study Teaching in Science, the Case Method Website of UC-Santa Barbara, and World History Sources.

Discussion techniques

Many faculty members dispense with lecture altogether, turning to discussion to prompt the kinds of thinking needed to build understanding. Elizabeth Barkley provides a large collection of discussion techniques focused on different learning goals, ranging from lower level to higher level thinking (Barkley, 2010). The CFT's Joe Bandy has summarized some of the most useful of these techniques.

Other approaches

There are other active learning pedagogies, many of which are highly structured and have dedicated websites and strong communities. These include team-based learning (TBL), process-oriented guided inquiry learning (POGIL),peer-led team learning, and problem-based learning (PBL). Further, the flipped classroom model is based on the idea that class time will be spent with students engaged in active learning.

How should you get started?

Start small, start early, and start with activities that pose low risk for both instructors and students. The Pause Procedure, retrieval practice, minute papers, and the think-pair-share technique provide easy entry points to incorporating active learning approaches, requiring the instructor to change very little while providing students an opportunity to organize and clarify their thinking. As you begin to incorporate these practices, it's a good idea to explain to your students why you're doing so; talking to your students about their learning not only helps build a supportive classroom environment, but can also help them develop their metacognitive skills (and thus their ability to become independent learners).

As you consider other active learning techniques to use, use the "backwards design" approach: begin by identifying your learning goals, think about how you would identify whether students had reached them (that is, how you might structure assessment), and then choose an active learning approach that helps your students achieve those goals. Students typically have positive responses to active learning activities that are meaningful, appropriately challenging, and clearly tied to learning goals and assessments (see, for example, Lumpkin et al., 2015). Finally, consult colleagues within your department and the Center for Teaching for help and feedback as you design and implement active learning approaches.

Other sources of information

There are many great sites that provide examples of active learning activities. Here is a sampling:

- National Center for Case Study Teaching in Science
- Case Method Website of UC-Santa Barbara
- World History Sources
- Online Teaching Activity Index
- Choose your own experiment biology labs
- Stanford Teaching Commons Activities to Boost Student Engagement
- MERLOT II (online resources)
- University of Michigan Center for Research on Learning and Teaching Active Learning page

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