# 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?

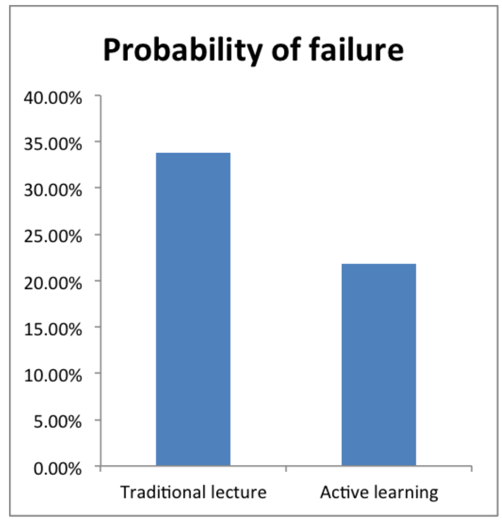
Constructivist learning theory emphasizes that individuals learn through building their own knowledge, connecting new ideas and experiences to existing knowledge and experiences to form new or enhanced understanding (Bransford et al., 1999). The theory, developed by Piaget and others, posits that learners 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, $Z = 10.4$, $P \ll 0.001$). 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, $Z = 9.781$, $P \ll 0.001$). 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)