Introduction

Active learning. *Active learning* is the introduction of activities to encourage students to create something -- and to think about what they are creating -- rather than just passively listening to a lecture. Educational researchers call this a "constructivist versus an exposition-centered method."

*Or simply: ask, don't tell. — jsu*

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*What is today’s university STEM context?*

![Bar chart showing percentage of faculty reporting "extensive lecturing" in "all" or "most" courses in STEM and other fields.](chart)

*Adoption lags*

Hurtado 2012

— jsu
Active learning works. A recent metaanalysis of 225 studies concluded that failure rates were reduced from 34% to 22%, and that this effect was significant across eight STEM disciplines. – jsu
Active learning decreases failure rates across eight STEM disciplines (more examples needed in computer science and geology though!) – *jsu*

Students are less likely to fail a class when active learning methods are used. – *jsu*
1. Break up the lecture

Students have a limited attention span. Studies testing recall of materials presented during traditional lectures indicate that students can only maintain focus for 10 to 18 minutes. After that, they need a 5 minute break to refocus and restart the clock.

Students remember 70% of information presented in the first 10 minutes of a lecture, but only 20% of information presented in the last 10 minutes. – jsu

[1]
A popular article by Khan (of Khan Academy) on the ineffectiveness of traditional lectures. – jsu

**Pauses during lecture.** In one study, a professor took a 45 minute lecture, and inserted three 2 minute breaks where students paired up and clarified their notes.

This simple activity led to dramatic improvements in short-term and long-term retention of class materials. – jsu
Without pauses during lecture, students scored an average of 81% on a final exam. After pauses were introduced, what do you think they scored? – *jsu*

A. 81%
B. 85%
C. 89%
D. 95%
Answer: (C)

Focusing on core concepts. A common objection to introducing pauses into lectures, or integrating even more complex activities, is that less time becomes available to cover course content.

One way to alleviate this issue is to think carefully what core concepts are critical for students to take away, and to leave prerequisite or supplemental material as separate items for students to explore on their own.

– jsu

2. Have students participate

Promoting student engagement. It's not enough for students to do something -- they need to do something which causes them to think about what they are doing.

This broad idea of activating higher level thought is termed student engagement. – jsu

Clickers!. Asking students to anonymously respond to a short closed-ended question is a great way of assessing where the class is at, and more importantly, of encouraging students to think about the material in an active way.

Make sure to keep the questions simple, and leave enough time to answer them (15-20 seconds for small classes, 30 seconds for larger ones). Also, don't overuse them! – jsu

[1]
Clickers in the Classroom: An Active Learning Approach

Further research will determine whether clickers complement or surpass other active learning approaches in improving learning outcomes

by Margie Martyn

Current research describes the benefits of active learning approaches. Clickers, or student response systems, are a technology used to promote active learning. Most research on the benefits of using clickers in the classroom has shown that students become engaged and enjoy using them. However, research on learning outcomes has only compared the use of clickers to traditional lecture methods. Although learning outcomes are higher when using clickers, the question is whether the clickers or the active learning pedagogies are the cause. For this reason, I conducted a study that compared learning outcomes resulting from the use of clickers versus another active learning method—class discussion. Even though both techniques employ active learning, would using clickers increase learning outcomes more than another active learning approach? Two key features distinguish clicker use:

- Clickers provide a mechanism for students to participate anonymously.
- Clickers integrate a "guess approach" that may engage students more than traditional class discussion.

The study also investigated students’ perceptions of their learning using clickers versus classroom discussions.

Active Learning

The benefits of active learning are widely acclaimed in higher education. According to Guthrie and Carlin, modern students are primarily active learners, and lecture courses may be

Clickers are a (good/bad) way to assess student understanding. Just make sure to make the questions (simple/complex), and give the students (a little/a lot of) time to answer them. – jsu

→ Answer: good, simple, a lot of.

Solicit responses to open-ended questions. Have students answer open-ended questions in writing. This is a core active learning strategy with many variants -- the activity can be done before,
At the start of class. This is called an entry ticket. Example:

"Based on the readings for your class today, what is your understanding of _______?" – jsu

In the middle of class. This is called a one-minute paper, and is just a response to any sort of written prompt.

The term itself is a bit optimistic -- it will usually take 2-3 minutes to complete, with 10 minutes total allocated for collection and review. – jsu

[2]
Classroom Activities for Active Learning

For well over a decade, the focus of the university classroom has steadily shifted from a teaching-centric approach to a learning-centric approach (Berk & Tigg, 1995). This shift calls for a rethinking of the traditional classroom, replacing the standard lecture with a blend of pedagogical approaches that more regularly involve the student in the learning process. Under a learning-centered approach, the instructor retains “control” of the classroom, but thought is regularly given to (a) how well students will learn the material presented, and (b) the variety of pedagogically sound methods that may be employed to help the students better understand the core information to be learned.

There is now strong empirical evidence that active involvement in the learning process is vitally important in two areas: (a) for the mastery of skills, such as critical thinking and problem-solving and (b) for contributing to the student’s likelihood of persisting to program completion (Barton, Jones, Hinchy, & Hartley, 2008; Frinco, 2004). Below are a few strategies that can be used by faculty in a wide variety of courses.

Questioning Techniques

For those who use lecture as the primary delivery method in the classroom, there are a few relatively easy methods to increase student involvement and interest in the classroom, regardless of course level or academic field. At the simplest level, this approach requires only asking questions during the lecture that challenge students to apply the concepts and principles introduced. Although most instructors would maintain that their students already ask questions during class, some college professors still devote only a small portion of class time to posing questions to students. Most of these questions are directed at the lowest cognitive level, requiring only recitation, clarification, or factual responses. Often only a small proportion of students regularly respond.

There are a few things an instructor can do to increase the number of different students responding in a given class period. One method is simply to change the way in which questions are asked. Periodically calling on students is a long-held method to determine which students are understanding the material and which are paying attention. The only downside to this approach is that some students are terrified to speak before a group, and when surprised with a quickly-delivered question the student may “freeze.” One approach that often helps students is to teach them to quickly sketch out a response to a question in their notes. When posing questions, pause for 15 to 30 seconds and then call on students. The length of the pause can be adjusted based on the cognitive complexity of the expected response. Another method is to give some “thinking” questions or calculations at the end of class and tell students the next class will begin with students being called on to respond to those items. Finally, it is sometimes helpful to focus attention on a small area of the class and wait for a response from a student volunteer. This increases “pressure” for someone in that area to respond.

In addition to getting a variety of students regularly responding to questions posed in the classroom, it is important that the responses increase in cognitive levels as the course progresses. To ensure that they ask questions from the higher cognitive levels, instructors who are adept at questioning usually prepare for class by writing their questions in the margins of their lecture notes or on their lesson plan. Also keep in mind that, although there are many degrees of cognitive complexity, for planning purposes three levels are particularly important: remembering, applying, and evaluating (Anderson & Krathwohl, 2001). At the lowest level, remembering questions help to ascertain whether the students have the facts.

http://cfe.unc.edu

University of North Carolina at Chapel Hill
Some Basic Active Learning Strategies

Engaging students in individual or small group activities—pairs or trios especially—is a low-risk strategy that ensures the participation of all. The sampling of basic activities below can be adapted to almost any discussion or lecture setting. Using these strategies, or variations on them, ensures that you'll hold your students' attention in class and throughout the semester.

<table>
<thead>
<tr>
<th>Ice Breakers</th>
<th>Scenarios / Case Studies</th>
<th>Shared Brainstorming</th>
</tr>
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<tbody>
<tr>
<td>Think / Pair / Share</td>
<td>Reciprocal Questioning</td>
<td>3 + 2 + 1 Format</td>
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<tr>
<td>Write / Pair / Share</td>
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<td>Student Summaries</td>
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<td>Question and Answer Pairs</td>
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<td>One Minute Paper</td>
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<td>Focused Listing</td>
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Ice Breakers

Those things that get people talking quickly and personally about their goals, fears, expectations for the session before them. Ask them, for example, to consider what one thing each hopes to gain from the workshop and what one thing each hopes to offer during the workshop, then have the group get up to move the room for five minutes gathering a sense of what others have come to gain and to offer. At the end of the workshop, this might become a way for individuals to measure what they've accomplished and gained overall. Or, as another example, you might consider having participants fill out a 3x5 card with their names and phrases/words in response to questions you've given all of them; the participants then don these cards as name badges and walk around the room meeting as many people as possible, interviewing others about the ideas/information on the card or large-size name tags; after five minutes you can ask participants to return to their seats and jot down names of folks who might be contacts after the session or jot down an individual goal for the session.
How can you incorporate active learning into the classroom?

There are many ways to use active learning in the classroom. The following brief list summarizes some simple approaches described by others (Active learning, n.d.; Felder & Brent, 1994; Felder & Brent, Fall 2003; Felder & Brent, Summer 1994; Pearson & Frost, n.d.):

- **Clarification Pause.** This is a simple technique aimed at resolving "issue spotting." Throughout a lecture, particularly after stating an important point or defining a key concept, stop, let it sink in, and then (after waiting a bit) ask if anyone needs to have it clarified. Or, ask students to review their notes and ask questions on what they've written so far.

- **Writing Activities such as the “Minute Paper.”** At an appropriate point in the lecture, ask the students to take out a blank sheet of paper. Then, ask the topic or question you want students to address; for example, "Today, we discussed convection heat transfer. List as many of the principal features of this process as you can remember. You have two minutes—go!"

- **Self-Assessment:** Students receive a quiz (typically ungraded) or a checklist of ideas to determine their understanding of the subject. Concept inventories or similar tools may be used at the beginning of the semester or the chapter for students to help students identify their misconceptions.

- **Large Group Discussion:** Students discuss a topic in class based on a reading, video, or a problem. The instructor may prepare a list of questions to facilitate the discussion.

- **Think-Pair-Share:** Have students first work on a given problem individually, then compare their answers with a partner and synthesize a joint solution to share with the class.

- **Cooperative Groups in Class (Informal Groups, Triled Groups, etc.):** Pose a question on which each cooperative group will work while you circulate among the groups answering questions, asking further questions, keeping the groups on task, and so forth. After an appropriate time for group discussion, ask students to share their discussion points with the rest of the class.

- **Peer Review:** Students are asked to complete an individual homework assignment or short paper. On the day the assignment is due, students submit one copy to the instructor to be graded and one copy to their partner. Each student then takes their partner's work and depending on the nature of the assignment plus critical feedback, corrects mistakes in problem solving or grammar, and so forth.

- **Group Evaluation:** Similar to peer review, students may evaluate group presentations or documents to assess the quality of the content and delivery of information.

- **Brainstorming:** Introduce a topic or problem and then ask for student input. Give students a minute to write down their ideas, and then record them on the board. For example, "What are possible safety (environmental, quality control) problems we might encounter with the process until we just designed?"

- **Case Studies:** Use real-life stories that describe what happened to a community, family, school, industry or individual to prompt students to integrate their classroom knowledge with their knowledge of real-world situations, actions, and consequences.

- **Hands-on Technology:** Students use technology such as simulation programs to get a deeper understanding of course concepts. For instance, students could use simulation software to design a radio antenna with the ultimate goal of understanding electromagnetism.

- **Interactive Lecture:** Instructor breaks up the lecture at least once per class to have all of the students participate in an activity that lets them work directly with the material. Students could observe and interpret features of images, interpret graphs, make calculations and estimates, etc.

- **Active Review Sessions (Games or Simulations):** The instructor poses questions and the students work on them in groups. Then students are asked to share their solutions to the whole group and discuss any differences among solutions proposed.

- **Role Playing:** Here students are asked to "act out" a part. In doing so, they get a better idea of the concepts and theories being discussed. Role-playing exercises can range from the simple (e.g., "What would you do if a client rejected your engineering design concept based on the cost and utility of the product?"") to the complex.

- **Jigsaw Discussions:** In this technique, a general topic is divided into smaller, interrelated pieces (e.g., the puzzle is divided into pieces). Each member of a team is assigned to read and become an expert on a different topic. After each person has become an expert on their piece of the puzzle, they reassemble the other team members about that puzzle piece. Finally, after each person has finished teaching, the puzzle has been reassembled and everyone in the team knows something important about every piece of the puzzle.

- **Inquiry Learning:** Students use an investigative process to discover scientific or engineering concepts for themselves. After the instructor identifies an idea or concept for mastery, a question is posed that asks students to make observations, pose hypotheses, and speculate on possible conclusions. Then students are asked to try to recreate the activity book to the main idea/concept.

- **Forum Theater:** Use theater to depict a situation and then have everyone enter into the skit to act out possible solutions. If students are watching a sketch on dysfunctional teams, have students brainstorm possible suggestions for how to improve the team environment. Then, ask for volunteers to try to act out the updated scene.

Active Learning Continuum.pdf Sep 25, 2014, 1:14:54 PM – jsu

At the end of class. This is called an exit ticket. Examples:

What questions do you still have?

What is the muddiest point? (concept you are having the most difficult with still?) – jsu
Interactive Classroom Activities

Students learn through their participation in the attainment of knowledge by gathering information and processing it by solving problems and articulating what they have discovered. Each activity below provides students with opportunities to deepen their learning by applying concepts and articulating new knowledge. Many of these activities also provide the instructor feedback about the students’ learning.

Entry/Exit Tickets

Entry & Exit tickets are short prompts that provide instructors with a quick student diagnostic. These exercises can be collected on “yes” cards, small pieces of paper, or through a survey or course management system.

- Entry tickets focus student attention on the day’s topic or ask students to recall background knowledge relevant to the day’s lesson; e.g., “Based on the readings, what is your understanding of...”

- Exit tickets solicit feedback on students’ understanding at the end of a class and provide the students with an opportunity to reflect on what they have learned. They can be helpful in prompting the student to begin to synthesize and integrate the information gathered during a class period. For example, a rewards point prompt: “What was the most difficult point in today’s class?” or “What questions do you still have about today’s lecture?”

Advantages of entrance and exit tickets include participation of each student, prompt for students to focus on key concepts and ideas, a high return of information, for the amount of time invested, rapid feedback for the instructor that can be useful to guide teaching decisions (e.g., course pacing, quick clarification of small misunderstandings, identification of student interests and questions).

Learn more about entry and exit tickets, and see examples.

Pair Writing/Minute Paper/Question of the Day Exercise

These are activities that prompt students to write a response to an open question and can be done at any time during a class. Writing activities are usually 1 minute, and can focus on key questions; and ideas or ask students to make predictions. These activities give students the opportunity to organize their own thoughts, or can be collected by the teacher to gain feedback from the students. Advantages include developing students’ abilities to think critically, and improving their writing skills.

Learn more about these strategies and see examples.

Ice Breakers

Ice Breakers are low-stakes activities that get students to interact and talk to each other, encourage subsequent classroom interactions. They can be useful at the beginning of the semester, for example, asking students to introduce themselves to each other and what they would like to learn in the course. Advantages of ice breakers include: participation of each student, the creation of a sense of community, and focusing students’ attention on material that will be covered during the class period.

Learn more about ice breakers and see examples.

Think-Pair-Share

This type of activity first asks students to consider a question on their own, and then provides an opportunity for students to discuss it in pairs, and finally together with the whole class. The success of these activities depends on the nature of the question posed. This activity works ideally with questions to encourage deeper thinking, problem-solving, and/or critical analysis. The group discussions are critical as they allow students to articulate their thought processes.

The procedure is as follows:

1. Pose a question, usually by writing it on the board or projecting it.
2. Have students consider the question on their own (1–2 min).
3. Then allow the students form groups of 2–3 people.
4. Next, have students discuss the question with their partner and share their ideas and/or contrasting opinions (3 min).
5. Have groups as a whole class and solicit responses from one or all of the pairs (5 min).

Advantages of the think-pair-share include: engagement of all students in the classroom (particularly the opportunity to give voice to quieter students).
this is implemented. One key finding: cooperative groupings help, but students must be directed by someone who knows what they are doing. – jsu


Powered by SKIES
3. Encourage collaboration

Collaboration helps. A particularly durable finding is that collaboration -- students working together directly -- and cooperation -- students working toward a common goal -- improves academic achievement, as well as student attitudes toward learning. -- jsu


M. Prince
Department of Chemical Engineering
Baylor University

Abstract

This study examines the evidence for the effectiveness of active learning. It defines the common forms of active learning most relevant for engineering faculty and critically examines the core elements of each method. It is found that there is broad but uneven support for the core elements of active, collaborative, cooperative and problem-based learning.

Introduction

Active learning has received considerable attention over the past several years. Often presented as a radical change from traditional instruction, it is frequently perceived as radical change from traditional instruction, the topic frequently polarizes faculty. Active learning has attracted strong advocates among faculty looking for alternative traditional teaching methods, while skeptical faculty regard active learning as another in a long line of educational fads.

For many faculty there remain serious questions about what active learning is and how it differs from traditional engineering education, since it is already "active" through homework assignments and laboratories. Adding to the confusion, engineering faculty do not always understand how the common forms of active learning differ from one another and most engineering faculty are not inclined to adopt the educational literature for answers.

This study addresses each of these issues. First, it defines active learning and distinguishes the different types of active learning most frequently discussed in the engineering literature. A core element is identified for each of these separate methods in order to differentiate between them, as well as to aid in the subsequent analysis of their effectiveness. Second, the study provides an overview of relevant caution for the reader trying to draw quick conclusions on the effectiveness of active learning from the educational literature. Finally, it assists engineering faculty by summarizing some of the most relevant literature in the field of active learning.

II. Definitions

It is not possible to provide universally accepted definitions for all of the vocabulary of active learning since different authors in the field have interpreted some terms differently. However, it is possible to provide some generally accepted definitions and to highlight distinctions in how common terms are used.

July 2004

[Reference]

Does Active Learning Work? A Review of the Research

Michael Prince
Department of Chemical Engineering
Baylor University

Abstract

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Cooperative learning helps with solving problems as well. – jsu

<table>
<thead>
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<th>Characteristic</th>
<th>Effect Size</th>
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<td>(b) Cooperative</td>
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<td>(c) Small group</td>
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<tr>
<td>(d) With non-expert tutors</td>
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<tr>
<td>(e) Self-paced</td>
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<tr>
<td>(f) Self-directed</td>
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<tr>
<td>(g) Using problems</td>
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<td>(h) Inquiry based</td>
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<td>(i) Instruction in problem solving</td>
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<tr>
<td>(j) Inductive</td>
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*Effect sizes associated with various aspects of problem-based learning.*

Cooperative learning helps with solving problems as well. – jsu

<table>
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<th>Reference</th>
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<th>Effect Size</th>
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<td></td>
<td>Improved quality of interpersonal interactions</td>
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<td></td>
<td>Improved perceptions of greater social support</td>
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<td></td>
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<td>Improved perceptions of greater social support</td>
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<td>Springer et al. [43]</td>
<td>Improved academic achievement</td>
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<td>Improved student attitudes</td>
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<td>Improved retention in academic programs</td>
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</tr>
</tbody>
</table>

*Table 1. Collaborative vs. individualistic learning: Reported effect size of the improvement in different learning outcomes.*

Effects of collaborative vs. individualistic learning – jsu

**Think-pair-share**. This means turning to your neighbor and discussing your thoughts with him/her before answering an open-ended prompt. – jsu

**Putting the pieces together**. Another effective strategy is called the *jigsaw approach*. Here the problem is divided into many pieces, and every student or group of students works on a
In a math class, students might solve an integral together, one person applying the product rule, and another the chain rule. In an English class, students might write stories together. – *jsu*

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**Job Summary.** Are you sick of eating food? Do you believe eating is overrated and too mainstream? Do you want to be an independent symbiotic organism who doesn't need people to grow food for you? Do you ever just want to stand around and eat without doing anything? Then become a test subject of our new symbiotic plant project "Flower Power"! All your food problems shall disappear in an instant. Just add water and you're good to go! – *rickyz*

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**Once upon a time...** There is a parrot who likes to imitate everything his owner says. All his previous owners find him annoying, so he has been abandoned 21 times until he met Larry, a little boy. – *lily0522*

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[1]

http://media.skieslearn.com/560a87756fb14110eed28cc0f89e2115.pdf