ACTIVE LEARNING: AN INTRODUCTION*

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You're about 30 minutes into your Monday morning energy systems class, and things are not looking good. At least a third of the students are texting or sleeping. Many of them clearly don't understand much of what you're saying (their midterm exam grades prove it), but they never ask questions.

It's been like this since the beginning of the semester and you are getting desperate, so you decide to try something different. You complete your determination of the energy output of a power plant boiler furnace and suddenly say "Suppose they build this exact furnace and the power output is only 380 MW instead of the 550 MW we just calculated. Get into groups of two or three, pick one recorder, and list as many possible reasons as you can think of for the difference, including violations of at least three assumptions in the calculation. I'll give you one minute and then call on a few of you. Go!"

The students quickly get into groups—some waking their neighbors in the process—and go to work. You stop them after about a minute, call randomly on several individuals for responses, get more responses from volunteers, and proceed with your lecture. The whole process takes less than three minutes, during which most or all of your students are awake and actively engaged with the course material. When you later ask them to do something similar on a test, surprisingly many of them can do it.

That's *active learning*.[1-5] Most college instructors have heard of it and know that pedagogical experts say they should do it in their classes. If you bring it up with colleagues, though, they will immediately tell you why it's a bad idea (an educational fad, a waste of class time, spoon-feeding, lowering academic standards, a radical conspiracy to destroy the American System of Higher Education, etc.). In this paper, we offer our definition of active learning; say a few things about how to do it; and try to persuade you that it's none of those evil things listed in the last sentence but just a simple, effective, and easy teaching strategy with a solid foundation in both research and common sense.

What is active learning?

If you think of anything a teacher might ask students to do—answer questions in class, complete assignments and projects outside class, carry out lab experiments, or anything else other than sitting passively in a classroom—you will find people who would classify it as active learning. We find that a more restricted definition limited to in-class activities is more useful:

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* Adapted from *ASQ Higher Education Brief, 2*(4), August 2009, and *Teaching and Learning STEM: A Practical Guide*, Ch. 6 (Jossey-Bass, 2016).

> Active learning consists of short course-related individual or small-group activities that all students in a class are called upon to do, alternating with instructor-led intervals in which student responses are processed and new information is presented.

The students may be asked to think about something or to do something, and must then be given time for the thinking or doing. An instructor asking a question and immediately calling on a student for an answer is not doing active learning by this definition. Similarly, giving students a stretch break in a long class session is an excellent idea, but what the students are doing is not course-related and so their activity isn't active learning.

Students retain much more of what they reflect on and do than of what they receive passively through their senses (such as the content of traditional lectures), which is one reason active learning is as effective as it has repeatedly been shown to be. You are doing active learning in your class when you ask a question, pose a problem, or issue some other type of course-related challenge; tell your students to work individually or in small groups to come up with a response; give them some time to do it; stop them, and call on one or more individuals or groups to share their responses.

We are not proposing that you give up lecturing and make every class you teach a total festival of activity. You know more than most of your students do about your subject (at least we hope you do), and you should spend part of your class time teaching them what you know—explaining, clarifying, demonstrating, modeling, etc. What we *are* suggesting is to avoid making lecturing the only thing you do. If a lecture or recitation session includes even a few minutes of relevant activity—a minute here, 30 seconds there—the students will be awake and with you for the remaining time in a way that rarely happens in a traditional lecture, and most will retain far more of what happens in those few minutes than of what you say and do in the rest of the session. If you do that in every course session, at the end of the semester you'll see evidence of learning unlike anything you've seen before. (Research cited in Reference 5 of the bibliography cites research data from hundreds of rigorous studies supporting that claim.) As you become more experienced, you may decide to increase the number of activities in each class session. There is no optimal amount—how many you do depends on the content of the class session and your comfort level with active learning.

What can you ask students to do?

It's limited only by your imagination. You can ask them to answer a question; explain a complex concept or a physical or social phenomenon in terms a high school student could understand; sketch a flow chart or circuit or free-body diagram or plot or time line or concept map; solve a short problem or outline the solution of a longer problem; get started on or carry out the next step of a case study analysis or long problem solution or derivation; predict or interpret the outcome of a scenario or experiment; critique a report or proposal or design or article or op-ed column; troubleshoot a malfunctioning system; brainstorm a list; formulate a question about the material you just lectured on for the past 20 minutes…we could go on, but you get the idea.

When you're deciding what to ask students to do, avoid trivial questions that the whole class should be able to answer immediately. Instead, focus on the hard stuff—the things students always have trouble with on assignments and exams. If you simply lecture on those things and you're a good lecturer, the students may leave class thinking that they understood everything, but when they get to the assignments they soon learn otherwise. If you use active learning, those brief interludes of practice and feedback in class will make the assignments and exams go a whole lot smoother for most of them.

What formats can you use for activities?

Here is the basic active learning structure.

1. For individual activities, go directly to Step 2. For small-group activities, tell the students to organize themselves into groups of 2–4 and randomly appoint a recorder in each group if writing will be required (e.g., designate as recorder the group member born closest to the classroom, or the one farthest to your right, or the one who woke up earliest that morning,…). Alternatively, tell the groups to appoint their own recorders, preferably someone who has not yet recorded that day.

   Note: For most group activities, four is a practical upper limit on group size. Unless the students are seated around small tables, four is the largest number that can interact comfortably, and even if there are tables, in groups of five or more some students are almost inevitably left out of group deliberations.

2. Pose a challenging question or problem and allow enough time for most individuals or groups to either finish or make reasonable progress toward finishing. The time you give them should normally be between 10 seconds and three minutes. (We'll talk about the reason for the upper limit a little later.) If they will need much more time than three minutes to solve a problem, break the problem into several steps and treat each step as a separate activity.
3. Stop the activity, call on several individuals or groups to share their responses, and ask for volunteers if the complete response you are looking for is not forthcoming. (You may occasionally ask for volunteers directly but don't do it after every activity, which is another injunction we'll discuss later.) Then discuss the responses or simply move on with your planned lecture.

The active learning literature offers many variations of this approach. Here are three particularly effective ones.

- *Think-pair-share.* Pose the problem and have students work on it individually for a short time; then have them form pairs and reconcile and improve their solutions; and finally call on several individuals or pairs to share their responses. This structure takes a bit more time than a simple group activity, but it includes individual thinking and so leads to greater learning.

- *Concept tests.* Ask a multiple-choice question about a course-related concept, with distractors (incorrect responses) that reflect common student misconceptions. Have the students respond using personal response systems ("clickers") and display a histogram of the responses. (Applications available online enable students to use their smartphones as clickers: for example, see *https://www.polleverywhere.com*). Then have the students get into pairs and try to reconcile their responses and vote again. Finally, call on some of them to explain why they responded as they did and then discuss why the correct response is correct and the distractors are not.
- *Thinking-aloud pair problem solving* (TAPPS). This is a powerful technique for helping students work through and understand a problem solution, case analysis, or text interpretation or translation. Have the students get into pairs and designate one pair member as the *explainer* and the other one as the *questioner*. Give the explainers a minute or two to explain the problem statement line by line (or explain the first paragraph of the case history or interpret or translate the first paragraph of the text) to their partners, and tell the questioners to ask questions when explanations are unclear or incomplete and to give hints when necessary. Stop the students after the allotted time and call on several individuals to explain things to you. Once you get a satisfactory explanation, have the pairs reverse roles and continue with the next part of the problem solution or case analysis or text interpretation or translation. Proceed in this manner until the exercise is complete. In the end, your students will understand the exercise material to an extent that no other instructional technique we know of can match.

You can see a 10-minute video of Dr. Felder using active learning in an engineering class at

(*https://www.youtube.com/watch?v=1J1URbdisYE*)

and a 35-minute video narrated by Drs. Felder and Brent of Dr. Felder using TAPPS in an engineering class

(*https://www.youtube.com/watch?v=0p7gNXGvcww*)

For more suggestions about how and how not to do active learning, read Reference 1.

Frequently-asked questions

Q: *What might keep active learning from working?*

A: Three mistakes instructors commonly make when they first get into active learning are (1) making group activities trivial, (2) making activities too long, and (3) calling for volunteers to respond after every activity. Why are they mistakes?

1. If you ask a question to which the answer is immediately obvious to most students and then ask the students to get into groups to come up with the answer, you're wasting their time, and they know it and will resent you for it. When you do an active learning exercise, make it challenging enough to justify the time group work takes.

2. If you give students, say, ten minutes to solve a problem, some groups will finish in two minutes and waste the next eight minutes of valuable class time, and others will struggle for the full ten minutes, which is extremely frustrating and also a waste of class time. Keeping the activities short (a good rule of thumb is 10 s – 3 min) avoids both problems.

3. If you always call for volunteers, the students quickly learn that they don't have to think about what you asked them to do—they can just relax and talk about the football game, and eventually someone else (probably you) will supply the answer. On the other hand, if they know that any of them could be called on for a response after a minute or two, most or all of them will do their best to be ready.

Avoid these three mistakes and active learning is almost guaranteed to work, even if you have hundreds of students in the class.

Q: *If I spend all this time on activities in class, how will I ever cover my syllabus?*

A: You can spend as much or as little time as you want to. Just a few minutes of activity in each class period will make a substantial difference in the learning that occurs in the class with at most a minor impact on the syllabus. To avoid losing any syllabus content at all, use *handouts with gaps.* Take most of the material you now spend a lot of time on—long prose passages, complex derivations and diagrams, etc.—and put it in handouts sprinkled with questions and gaps. Have the students read through the straightforward material in class (they can read much faster than you can write or drone through PowerPoint slides), and either lecture on the gaps or (better) use them as bases for active learning exercises. You'll cover more material than you ever did when you said every word and did every calculation yourself, and the quality of learning will be much greater. (For more details on this strategy and research attesting to its effectiveness, see Reference 6 in the bibliography.)

Q: *Won't it take me a lot of time to plan activities?*

A: Preparing good lesson plans for a new course is a huge task, whether or not the lessons include activities, but adding activities to lesson plans should not take much time. Just look over your lecture notes a few minutes before class, think of some things you might ask the students to do, and jot them down in the notes. You'll always come up with as many activities as you want, and after one or two iterations of the course the ones that work well will become a permanent part of the lesson plans.

Q: *What if some of my students don't like being asked to work in class?*

A: Some probably won't, especially when you first start doing it. Many students want their instructors to tell them everything they need to know for the exam—not one word more or less—and if they are made to work in class they resent it. The key is to let them know up front that you are doing active learning not for your own selfish purposes but because you have research showing that students taught this way have an easier time with homework and do better on exams. Reference 4 in the bibliography ("Sermons for Grumpy Campers") gives details on how to make that case persuasively, and Reference 5 reviews the research. It won't take the students long to find out that you're telling them the truth, at which point the complaining will stop.

Q: *What should I do if some of my students refuse to get into groups when I ask them to?*

A: The first time you do an active exercise in a class unaccustomed to active learning, many students might just stare straight ahead, and you will have to personally encourage some of them to work with each other. By the second or third time you do it, there should be few if any holdouts. At that point, stop worrying about it. The research shows that students learn much more by doing things and getting feedback than by watching and listening to someone tell them what they're supposed to know (Reference 5). In your class activities, you're providing practice and feedback in the things you know the students will find difficult on the homework and tests. If some choose not to take advantage of those opportunities, it's their loss—don't lose five seconds of sleep worrying about it.

And that's all there is to it. Instructors who switch to active learning and follow those recommendations almost always say that their classes are much more lively and enjoyable and the quality of learning goes up dramatically. Try it in the next course you teach, and see if you don't have a similar story to tell by the end of the semester.

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To take a multiple-choice quiz on the content of this tutorial with feedback on incorrect responses, go to

https://www.engr.ncsu.edu/stem-resources/legacy-articles/education/active-learning-introduction/

Follow the directions to have the tutorial and the quiz open on different browser tabs, so you can easily go back and forth between them.

Bibliography

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Tables extracted from:

Barrasso, Anthony P., and Kathryn E. Spilios. "A Scoping Review of Literature Assessing the Impact of the Learning Assistant Model." *International Journal of STEM Education*, vol. 8, no. 12, 2021, pp. 1-18.

Table 1 A summary of studies referenced in this paper that assess one or more of the original goals of the LA model (see text for details of goals)

Authors (year)	Goal	Experimental design	Summary statement
Alzen et al. (2017)	1	Quasi-experimental	DFW rates improved in introductory physics courses after the implementation of the LA program.
Alzen et al. (2018)	1	Quasi-experimental	DFW rates improved in introductory STEM courses after the implementation of the LA program.
Barr et al. (2012)	2	Quasi-experimental	In-service science and math teachers that were formerly LAs have significantly different classroom practices than their non-LA colleagues.
Campbell et al. (2019)	2	Pre-experimental	LAs and faculty both perceive improvements to collaborative learning due to LA support, but improvements to LA and faculty training could improve the effectiveness of the LA program
Caravez et al. (2017)	3	Quasi-experimental	Teaching without LAs is associated with a steady decline in concept learning for students, but instructors that teach with LAs do not experience the same decline in learning for their students.
Close et al. (2013, 2016)	1	Pre-experimental	Being an LA promotes a stronger physics identity.
Cochran et al. (2016) and De Leone et al. (2019)	4	Pre-experimental	The LA program can facilitate partnerships between two-year and four-year colleges that are beneficial, but require consistent communication between the institutions.
Conn et al. (2014)	2	Quasi-experimental	First semester LAs communicate unease with respect to teaching and learning that is not seen with more experienced LAs.
Gray and Otero (2009)	2	Quasi-experimental	Both LAs and non-LAs recognize that group work is important, but non-LAs more often express concerns with their ability to successfully use group work.
Gray et al. (2010)	2	Quasi-experimental	Former LAs teaching practice is more in line with national standards and evidence-based practice than non-LAs.
Gray et al. (2012)	2	Quasi-experimental	Former LAs are more likely to use formative assessment than non-LAs.
Gray et al. (2016)	2	Quasi-experimental	Former LAs more commonly use evidenced-based teaching practice, especially early in their careers.
Herrera et al. (2018)	1	Quasi-experimental	Coupling LA support with collaborative learning is correlated with higher learning gains than collaborative learning alone.
Knight et al. (2015)	1	Quasi-experimental	Content and length of small group discussions about clicker questions are impacted by the presence of an LA and the techniques used by LAs.
McHenry et al. (2009)	3	Pre-experimental	LA-faculty partnerships help to expand the conceptions about teaching and learning for both faculty and LAs.
Miller et al. (2013)	1	Quasi-experimental	Improved learning gains are observed in LA-supported introductory physics courses.
Nadelson and Finnegan (2014)	1	Pre-experimental	The knowledge and leadership skills needed to excel at the LA position leads to the development of stronger professional identities.
Otero et al. (2006, 2010) and Otero (2015)	1,2,3	Pre-experimental and quasi-experimental	The LA program engages students and faculty in teaching as a practice and career and improves student learning gains.
Price and Finkelstein (2008)	1	Quasi-experimental	Physics LAs have significantly higher learning gains than students who taught or conducted research in other environments.
Quan et al. (2017)	2	Pre-experimental	LAs view convergent/divergent thinking and design thinking as the most productive concepts in their pedagogy course and classroom role play as the most productive activity
Robertson and Richards (2017)	2	Pre-experimental	"Sense-making" helps LAs more attentive to student thinking and helps them recognize the importance of responsiveness as a component of good instruction.
Sabella et al. (2016)	3	Pre-experimental	LA-faculty partnerships range from being mentorships to being collaborative where faculty and LAs learn from each other.
Sellami et al. (2017)	1	Quasi-experimental	Students in LA-supported courses performed on better exam questions that require higher order cognitive skills, and this difference is greater among underrepresented minority students.
Shi et al. (2010)	1	Quasi-experimental	Learning gains for LAs in Introductory Molecular and Cell Biology are better than non-LAs, but lower than "experts".
Thompson and Garik (2015)	1,3	Pre-experimental	Students are satisfied with their LAs, but their focus is mainly on grades, while LAs emphasize learning for conceptual understanding.

Table 1 A summary of studies referenced in this paper that assess one or more of the original goals of the LA model (see text for details of goals) *(Continued)*

Authors (year)	Goal	Experimental design	Summary statement
Top et al. (2018)	2	Pre-experimental	It is critical to use accessible language when teaching pedagogical concepts to first semester LAs.
Van Dusen and Nissen (2019)	1	Quasi-experimental	LA support is associated with decreased DFW rates for all students and larger decreases for students of color.
Van Dusen et al. (2015)	1,3	Quasi-experimental	LA support correlated with a reversal of traditional learning gaps between race, and student outcomes improved when 16-30 minutes/week were spent with LAs and when instructors had more experience teaching with LAs.
Van Dusen et al. (2016)	1	Quasi-experimental	LA support correlated with an elimination and in some cases reversal of traditional learning gaps between race and gender in physics.
Van Dusen and Nissen (2017)	1	Quasi-experimental	LA support is correlated with improved outcomes for all students.
Wendell et al. (2019)	2	Pre-experimental	LAs notice student misconceptions and common errors in thermodynamics.
White et al. (2016)	1	Quasi-experimental	LA usage is associated with improved concept inventory scores, and the improvement is largest when LAs are used in a laboratory setting.

Table 2 A summary of studies cited in this article that reference LAs, but do not assess any of the original goals

Authors (year)	Summary statement
Becker et al. (2016)	LAs and teaching fellows have generally similar views on the roles of LAs, teaching fellows, and professors, with some different perceptions of the responsibility and influence of teaching fellows.
Davenport et al. (2017)	The Preparation Session Observation Tool is a valuable tool for reflecting on LA partnerships with faculty, teaching assistants, and other staff.
Cao et al. (2018)	LAs in engineering perceive their roles primarily as communicators and identify communication skills and deep content knowledge as critical skills for being an LA.
Chini et al. (2016)	Training LAs with a virtual classroom simulator allows them to practice critical skills and informs faculty of shortcomings in LA training.
Cochran et al. (2013)	A framework to assess LA written reflections and provide feedback to improve reflective writing was described.
Cochran et al. (2013)	Reflecting on teaching is a valuable practice for LAs because they allow for reevaluation and in some cases changes to teaching styles.
Goertzen et al. (2013)	The LA program provides an opportunity for underrepresented minority students to form connections with members of the Physics Department and become better physics learners.
Talbot (2013)	Using an item-level approach to assess concept inventory results as opposed to a student-level approach can provide more detailed insight into student learning gains.
Talbot et al. (2016)	The CHAT framework serves a model to measure and describe student success associated with LA course transformation.

Table 3 Studies that use the LA model, but as only a part of or in addition to another intervention

Authors (year)	Intervention
Baily (2011)	Transformation of a physics curriculum that improved student understanding of indeterminacy and wave-particle duality
Bonham et al. (2018)	Comprehensive teaching model that improves science writing skills
Brown-Robertson et al. (2015)	Transformation of an economics course at a historically black university.
Bullock et al. (2015)	Transformation of a first semester calculus,
Callahan et al. (2014)	Development of a STEM "identity" on a large metropolitan campus
Chasteen et al. (2011)	Developing assignments and writing clicker questions
Co (2019)	In-class skill-focused content related practice in large lecture course
Cracolice and Queen (2019)	"Active recitation" in introductory chemistry
Elliott et al. (2016)	Transform of introductory biology to include more active learning
Foote et al. (2016) and Knaub et al. (2016)	SCALE-UP instructional reform
Franklin et al. (2018)	Project IMPRESS for deaf/hard-of-hearing and first-generation students
Geller et al. (2019)	Development of an introductory physics course that helped life science students develop cross disciplinary knowledge
Goertzen et al. (2011)	Open Source Tutorials
Goldhaber et al. (2009)	Transformation of a quantum mechanics course
Jeffery et al. (2019)	"Context-based" chemistry
Klymkowsky (2007)	Transformation of Molecular, Cellular, and Developmental Biology course that replaced a standard textbook with an online resource
Koretsky et al. (2016)	Evidence-based instructional practices in calculus-based introductory courses
Koretsky (2017)	Audience response systems and guided inquiry worksheets
Moore (2018)	Multimedia learning modules
Nelson (2011)	Oral assessments
Newman et al. (2018)	Model-based instruction in a Cell and Molecular Biology course
O'Shea et al. (2013)	Transformation of a physics course for life sciences majors
Pollock (2007, 2009) and Pollock and Finkelstein (2007, 2008, 2013)	"Introductory to Physics Tutorials" (guided-inquiry worksheets)
Price et al. (2011)	Archiving in-class student white board work for use outside of the classroom
Stone et al. (2018)	Preparatory course for underprepared first year general chemistry students
Tsai et al. (2013)	"Body-Based Approach" to teaching Engineering Statistics
Wilton et al. (2019)	Transformation of an introductory biology course

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From: **https://academicaffairs.kennesaw.edu/supplementalinstruction/**

Learning Assistants

Based off the international Learning Assistant model, the Kennesaw State University (KSU) Learning Assistant Program places high achieving undergraduate students in courses they have previously completed to support KSU's student success efforts. These Learning Assistants, or LAs, assist students in developing strategies that will help strengthen their knowledge, develop transferable learning skills, and achieve academic success.

LA responsibilities may include working with small groups of students; reviewing clicker questions, practice questions, or other exercises; team teaching recitation or laboratory sections with a graduate teaching assistant or faculty mentor; or facilitating online discussions and other learning activities that take place during class meetings. Having successfully completed the course where they serve as an LA, LAs will be able to guide or coach students by sharing skills and knowledge, as well as by communicating confidence and encouragement. LAs also serve as an example - demonstrating how to successfully approach academic challenges.

- Goals and Structure of the LA Program +
- Learning Assistant Qualifications +
- Become an LA +
- Resources for Faculty +

<u>From</u>: https://academicaffairs.kennesaw.edu/student_resources/learning-assistants.php