Starting Small with Active Learning

Hannah Allen, Chemistry G6
Jaron Tong, Chemistry G2

Outcomes: By the end of the session, participants will be able to...
- understand why using active learning is important
- identify different active learning techniques and understand in what situations they might be useful
- feel comfortable making a plan to implement active learning while teaching

---

Introduction

Active learning – defined as educational methods in which ALL STUDENTS are asked to engage in the learning process WHILE IN CLASS – has been shown to improve student learning and retention in STEM fields. Research has shown that active learning helps enhance material retention and student motivation by making students an active part of the learning process. These materials will explore some active learning techniques and help you get started planning how to use them. Implementing active learning in your classroom doesn't have to be a complicated endeavor!

Categories of active learning used here

The active learning techniques explored here are divided into three categories based on their level of instructor interaction and complexity in managing group dynamics. The levels are:

1. Quick and easy – requires little to no preparation
2. Moderate effort – some preparation, some group management
3. Slightly more involved – moderate preparation, more involved group management

Quick and Easy activities

This section presents several methods of active learning that are the most accessible to start with and that require relatively low preparation beforehand. The techniques in this section typically have little instructor interaction with students beyond initially framing the question and managing the time for the given activity. As a result, these activities can be done quickly, informally, and on the fly.

Brainstorming

Brainstorming is one of the simplest techniques to quickly get students talking and reflecting on the material. It can be done in the middle of class with no preparation. This technique also encourages students to draw on prior knowledge and experiences.

How it works: Students are asked to generate ideas on a certain topic, category or question while you facilitate and record the answers on the blackboard or whiteboard.

Instructor notes: It is important to acknowledge all answers during the idea generation period. Brainstorming can be adapted to small or large classes, in any discipline and any length of time.

Think-Pair-Share

A simple technique to quickly get students to analyze and discuss course material together. Think-pair-share can be a planned component of class time or can be used to mitigate extended silence after the instructor asks a question. A question previously met with crickets often prompts lively discussion once students are asked to talk amongst themselves rather than directly to the instructor.

How it works: Think-pair-share is a three-step process. 1. students think independently about a question posed by the instructor; 2. students pair up with a neighbor and discuss their thoughts with each other; 3. class is asked to share with the class as a whole what their pairings discussed.

Instructor notes: Set timing guidelines, such as "think for 30 seconds, pair for two minutes, and three people share what they discussed in their respective pairs". Think-Pair-Share is most effective when the debrief elucidates a few key points. This technique gets virtually all students involved; even if they don't share what they discussed, they still will have discussed in their pair and have engaged with the material.

Minute Papers

Minute papers are a type of classroom assessment technique that tests how students are gaining knowledge, or not, and are usually administered at the end of class. This technique engages students by requiring that they take a few moments to reflect on the day's material and think about what directions the class might be going.

How it works: The instructor asks students to write a brief response to questions such as "What was the most important thing you learned during this class?" or "What important question remains unanswered?" or "What was the muddiest (most unclear) part of class?"

Instructor notes: Minute papers serve as a type of feedback for the instructor by showing how well instructor-set learning outcomes align with what students are getting out of the class as well as highlight areas of confusion for students.

Moderate Effort activities

Medium active learning techniques require slightly more preparation and perhaps more time to implement than the simplest techniques. These often take the form of peer instruction, most commonly executed as "clicker questions."

One-stage clicker questions

Clicker questions are used to assess prior knowledge, misconceptions, or student understanding of material presented so far in class. Each student is required to respond, thus getting every person involved with at least minimal engagement with the material that is absent in a lecture-only setting.

How it works: The instructor poses a question to the class with a list of potential answers. Each student uses a clicker (see below) to select their answer and send their response to the instructor. After all responses are collected, the instructor can review the responses, providing further explanation for why certain answers are incorrect as they feel necessary before moving on.

Instructor notes: This technique gives immediate feedback about how well students understand course material. However, clicker-type questions are more effective when they go beyond and into a second stage that involves peer instruction.

Two-stage clicker questions

While asking students to answer clicker questions is a start to implementing active learning in your classroom, you can take this further by including peer instruction through two-state clicker questions. Peer instruction has been shown to more effectively correct students' misconceptions than explanations from the instructor alone (Mazur 2001). In this approach, students are actively engaged with each other in correcting wrong answers and misconceptions. Generally, students are more convincing to each other because they understand why their peers don't understand a given concept.

How it works: As in the one-stage clicker question, the instructor poses a question to the class with a list of potential answers. Students select one of the options using a clicker. However, in the two-stage method, the instructor doesn't provide explanations before continuing with the class. Instead, they ask students to engage in peer discussion in pairs or small groups. In these discussions, peers can discuss why they think a certain answer is correct, re-affirming their reasoning behind the answer. If peers do not agree, peer discussion is used to try to convince the other parties to change their answers. After students have had time to discuss, the question is posed again, often with a different trend in responses.

Instructor notes: This method is recommended when 30-70% of responses are correct; lower correct response rates may require revisiting the concepts, but higher correct response rates might see diminishing returns on using peer instruction.

Clicker question technologies

There are several types of clicker question technologies, ranging from low tech (i.e. without electronics) to high tech:

- **Voting by hand –** Students either raise their hands (for questions with two possible answers) or, for a more anonymous response, hold their hands up to their chest with one, two, three, etc. fingers up.
- **Folded paper cards –** Each student has a sheet of paper folded into quarters such that each quarter has a different response (e.g. A, B, C, D). To respond to a question, students hold up their folded paper such that their response is visible. For easier visibility for the instructor, each quadrant can be printed to have a different color background.
- **Plickers –** Plickers (https://www.plickers.com/) allow up to 64 students to individually respond to a question by holding up a piece of paper with a bar code in one of four orientations. The only electronics required are that the instructor have the Plickers app downloaded, which allows them to scan the room with their smartphone camera and compile summaries of their students' answers.
- **Clickers –** The conventional clicker technique requires that all students have their own remote-control-type device which they use to respond to questions. Their answers are compiled by software and can be displayed after responses are recorded.
- **Poll Everywhere –** Poll Everywhere (https://www.polleverywhere.com/) is a versatile application that can be used to collect responses for multiple choice questions, record short answers, and collect instantaneous feedback (e.g. muddiest points) anonymously. However, this technology requires that all students have a smartphone, tablet, or laptop computer with internet access and may not be usable in classrooms where not all students have access to these devices or that have poor wireless internet connection.

Slightly More Involved activities

This group of methods involves some additional considerations, often because students are collaborating for longer periods of time and need clear instructions to make their work productive. The following methods are still very accessible with a little bit of planning.

Whiteboard (or chalkboard) tasks

Discussions using a conventional wall-mounted whiteboard or chalkboard or using lap/desk-sized erasable boards have been shown to be an impactful, yet low-tech, way to enable active learning in classrooms. This technique has the advantage of being more open-ended, but requires planning to have erasable boards available, and clear instructions for what students will write down.

How it works: Using either wall-mounted or desk/lap-sized whiteboards or chalkboards, small groups (usually pairs; groups of three at most) carry out learning-related tasks and record their answer or process on their erasable board. The questions they work on could be similar to clicker or peer instruction questions discussed above, but instead of voting or using clickers, groups record their thinking, reasoning, steps, or ideas on the board.

Instructor notes: It is important to have a plan for following up on their whiteboard work. For example, will you as instructor of TA circulate and choose one or two boards to show and discuss with the class? Will groups check and discuss their own work?

Extended problem solving in groups

In this method, students work extensively in their groups and may spend the majority of the class period discussing with their peers rather than interacting directly with the instructor. Each group works together on a set of problems – either all on the same problems, or on different problems - thus providing a great implementation of peer instruction. Groupwork may be done on a space of wall-mounted chalk or whiteboard or on inexpensive "cling sheets" of temporarily, plastic whiteboard material that are available for rooms with smooth walls where more whiteboard space is needed.

How it works: The instructor or teaching assistant typically provides a brief introduction to the key concepts of the day or week at the beginning to get everyone on the same page. Then, groups of approximately three (no more than four) students actively work through example problems with one another. The instructor or TA circulates and monitors groups to make sure that everyone is involved, different students get a chance to hold the marker or chalk and write the group's progress, and that all of the students in the group can answer questions about how and why the group is choosing to solve the problems.

Instructor notes: If all students are working on the same problem, when the first one or two groups are nearly finished, it's time to bring everyone back together and talk through it together. It's ok if not everyone finished the problem as you will discuss it. In this case, as you discuss the problem with the whole class, call on the groups that didn't quite finish for early steps, and the groups that finished to supply later steps. If students are working on different problems, you can have them share with one another how they started or approached the different problems.

Group guidance for next level methods

For the methods discussed in this section, it's helpful to keep in mind that college students may not all be experts in collaboration and group work. You can help them be effective in groups by giving them guidance:

- **Optimize group size for participation** – Unless you have a lot of very specific roles or tasks within a group, more than three or four people per group often means that one or more of them will not be active or engaged in the work.
- **Give guidance on roles** – The POGIL (Process Oriented Guided Inquiry Learning) technique, another more extended active learning method, has developed the following student roles to help groups work well: Manager, Presenter, Reflector, Recorder (www.pogil.org/educators/resources, see "Role Cards" link for definitions). Make sure students each have a role when groups get started, especially on extended tasks, and give students opportunities to have different roles throughout the term.
- **Let students know that groups will change** – Whether you assign groups or let students form their own (and there is no single answer to which is better), in many instances it is helpful to let them know you'll be switching things up at some point. This allows you to intervene if certain groups really do not get along (even with the above ideas in place), and to give students experience collaborating with a wider variety of peers (an important skill to practice). *NOTE: If students are working on an extended project together, or when collaboration skills are a main course learning outcomes, keeping groups together for longer periods or an entire term may be important; in that case, make sure you pay special attention to group roles, accountability, and put in place a process for groups members to give and receive feedback to improve group functioning over the course of the project or term.*

Making a plan for your upcoming teaching roles

Here are some questions to ask yourself in order to help you choose among the methods above.

- How much time are you willing to devote to active learning per class?

- How comfortable are you now with student discussion and interaction?

- How many students would you be engaging in active learning?

- What is your purpose (e.g. real-time feedback, peer teaching) in implementing active learning?

- Do you have access to the resources necessary to make this activity successful?

Additional Resources

Classroom Assessment Techniques (CATs)
https://cft.vanderbilt.edu/guides-sub-pages/cats/

Peer Instruction
https://www.uq.edu.au/teach/flipped-classroom/docs/FAB/FABPeerInstructionTipsheet.pdf