**Summary:** This instructional methodology is any learning event in the classroom that requires a student to actually do something (active engagement) as opposed to passively receiving information, like sitting - just listening to a pure lecture class. Or as researchers Charles Bonwell and James Eison from the Association for the Study of Higher Education put it, "to be actively involved, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation" (1991, p. 5). The key to this instructional technique is that the focus is on student learning (student-centered learning), not on the instructor teaching. There is a large continuum of active learning activities that run from partially to highly engaging. The best learning activity depends on the learning material, resources available, and learning objectives.

Benefits: The following benefits of active learning have been identified through numerous research studies in both STEM (Science, Technology, Engineering, and Mathematics) – *to include newer fields such as Data Science/AI,* and humanities subjects (Freeman et al., 2014; Intel, 2021; Michael, 2006; Prince, 2004; Rosario, 2021; Rosenthal & Chung, 2020):

- **high student engagement**
- **helps students better master difficult subjects**
- **high student motivation and enjoyment**
- **highly *evidenced-based* instructional technique**
- **better grasp of topic theory and application**
- **increases student class attendance**
- **general enhancement in communication skills**
- **better recall of information learned**

Bloom's Revised Taxonomy

Create

Evaluate

Analyse

Apply

Understand

Remember
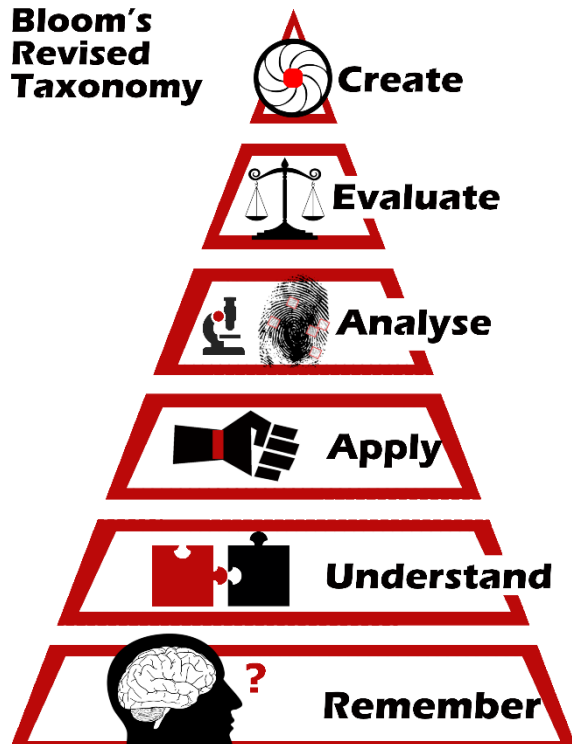
3 Key Questions: When deciding on an active learning activity, ask yourself the following three questions to achieve the most educational impact in meeting the desired course learning objectives/goals (Bonwell, 1996).

1.   What do I want my students to KNOW (what is the knowledge they need to gain)?

2.   What do I want my students to DO (what skills/capabilities should they be able to accomplish)?

3.   What do I want my students to FEEL (what attitudes/realizations should they obtain)?

Answering these questions and using Bloom's Revised Taxonomy (Bloom, 1956; Krathwohl, 2002) helps to understand the best type of active learning activity to use within your class.

Image used with permission (Anders, 2021)

Process, Implementation Ideas: The following is a listing of active learning activities (*not exhaustive*) that can be used within your classroom to make the topic being learned more engaging and hands-on. The following list starts from being minimally active to more active. Realize that some activities take longer than others, and some allow for multiple implementations within the same class. Always consider how to help students reflect on what they have done/learned and help them see and realize the relevance. The key is to always consider the learning objectives, material, resources, and time available.

• **Enhanced Lecture (Presentation):** Instructors still need to explain information and clarify but the way this is done has an impact on student learning and motivation. Avoid long lectures where you are static, at the podium, or board and just lecturing/talking to the students for the entire class. Avoid being boring and dry. Instead, use proper verbal and non-verbal communication (Speech 101) techniques to give a dynamic presentation (with visuals) and at a maximum 15 to 20 minutes (less if possible) – (Bonwell et al., 1991; Cashin, 1985; Pi et al, 2016). Whenever possible (as appropriate) engage the students in a more active manner (such as with the other active learning activities presented below).

• **Polling:** Posing a question to the entire class and asking for their response (via raising hands, holding up colored cards, using clickers, or other online means) makes students think about the question/material and generate an answer/opinion on the question posed. This requires very little time and is an easy way to get students involved: active.

• **Questioning:** Asking direct questions to students throughout the class can be a quick and effective way to gauge understanding and increase student engagement. Some useful questioning techniques: open questions, closed questions, ask the class, ask a specific student, ask another student a follow-on question based on previous student's response, ask students to come up with questions that other students might have. Use many different techniques and find what works best for your class, topic, or activity.

Generally, use the *Ask, Pause, Call* process so that all students have a chance to process and contemplate the questions asked. *Ask* the question so all students understand; *Pause* a few seconds to let everyone think about it; *Call* on either a student that has their hand up or not and work through the answer. – All students should feel that they could be called on at any time to help answer the question.

• **One Minute Paper:** This activity is powerful because it forces students to think and involves everyone. Pose a question such as: "what was the muddiest point, something you didn't understand from today's class," 'what was your favorite part of today's class," "what was the key concept taught in today's class," or whatever you feel would be a good short question. This can be one, two, three minutes, or more, but works best when kept short to allow for quick reflections. These one minute papers can then be collected for participation points, used as part of students' reflective journals, evaluated as valuable instructor/class feedback, or used as part of a follow on discussion. The key is that students had to actively think and write out their thoughts – engaging in the material and class.

• **Discussion:** This is different than just asking questions. Here the entire class is involved, offering their thoughts, views, and opinions. The instructor guides and focuses the discussion encouraging everyone to participate and preventing anyone from dominating the conversation. This activity takes time and effort but is very rewarding, empowering, and develops many skills beyond the topic being discussed.

> **Coaching Discussion:** An interesting discussion implementation that works well in a lot of STEM courses involves inviting a student up to the board to solve a problem whose theory was just explained. The instructor has the student go through the problem section by section. The student not only goes through and solves the problem, but verbalizes what they are doing. If they run into an issue or gets stuck, the instructor asks questions of the student or other students in the class and they all work to coach the student through the rest of the solution.

• **Think Pair Share:** this active learning activity involves several engaging processes but takes very little time and can easily be done in both smaller and large classes. The instructor poses a question or problem and then gives the student a moment to think about the answer (you can have them write it down if that would be appropriate). Then, you have the students pair up to discuss their ideas/solutions with one another. As they are sharing with one another tell them to agree on a solution/answer and prepare to share it with the class (give them a general time limit). Now have each pair share what they have come up with to the rest of the class.

• **In-Class Worksheets:** Worksheets have been used in education for a very long time, but are generally given as homework. To make these worksheets function as an active learning activity, first introduce the topic, explain the process/idea, and then have students use what they have learned in order to complete the worksheet. This can be done in different ways such as having the student work independently, with a partner, but ultimately discussing the results and the correct answers with the entire class.

• **Case Studies/Problem Based Learning:** After a brief explanation of a real-world problem/situation, students are given time (either individually or in groups) to go through in-depth information and come up with possible solutions. These solutions are then discussed in class where students must be able to properly express (and defend) their ideas/solutions.

• **Project Based Learning (Group Work):** Students work in groups on a larger real-world project, some class time is used to work on the project, discuss their progress, and ask questions. Each group is then expected to present their finding (real-world solutions) to the class/public). Groups of 3 or 4 tend to work best and some guidance should be given regarding conflict resolution and how to manage working in a team.

• **Student-Led Instruction:** Students are assigned a topic along with specifics and informed that they will give an instructional presentation to the class. Students then research and deeply learn the topic, create an instructional class presentation, submit it for review, and then present it to the rest of the class. Key components are to require personal/modern analogies and examples in order to maximize content relevancy and the impact of peer learning. Inclusion

of student-led *active learning* as part of the student-led instruction would also be a plus and help in the learning process.

• **Scenario/Role-Playing/Simulations:** Creating a situation where students have a greater connection to the content due to heightened realism through scenario building and/or role-playing can greatly enhance students' understanding, motivation, retention, and skills transfer. Describe a realistic environment and situation where students must use the skills/knowledge learned to role-play through and successfully complete the event.

As an example, after learning about proper interviewing techniques, have the students go through the process and interview a fellow student, setting up the scenario to make it more realistic. Another technique is to have a student interview you in front of the class based on a created scenario and have the students take notes and prepare to discuss what they observed. The more you can do to enhance realism and detail the more interesting and engaging it tends to be. As always, ensure a safe learning environment, where students know that failure or messing up in the classroom is a great learning experience for all. Use proper judgment in deciding when and how to use this powerfully engaging active learning activity.

• **Games:** This type of activity can be done in many different ways but generally involves increasing the fun component in presenting or reviewing instructional materials. One implementation would be through a game show activity where students are divided into two teams and then have to answer different questions about the learning material. Key considerations are to make it fun (visuals and processes), engaging (keep track of team points to increase low stakes competition motivation), and ensure maximum participation (done by the way the game is administered). Jeopardy and Family Feud are popular game shows that can be adapted for use in the classroom.

• **Labs:** Generally viewed as a very high-level active learning activity, having a lab entails letting students physically use, manipulate, and create aspects of what was instructed. Some examples of this would include actually writing out a computer program, mixing chemicals, and constructing electrical products (such as robots or other machines). Labs should be timed to properly coincide with applicable instruction allowing for hands-on usage and implementation of theory (instruction) learned.

Overcoming Students' Concerns or Objections: Although there are large amounts of research that indicate the benefits of active learning over passive learning (*see all citations previously given*) and although most students will highly enjoy and be motivated by more active learning, there might be some students that could become anxious at not simply having all the information and answers given to them in a direct lecture. To address these concerns, the following techniques/responses should be used (Tharayil et al., 2018):

1) Inform Students and Explain the Purpose: From the very beginning, tell students that there will be more to the course than just lecture and explain that active learning will be used because it is more effective in helping them learn the material, make better connections, and will help them develop practical skills – always explicitly show the connections and relevancy.

2) Explain Course and Activity Expectations: Inform students that there will be different types of activities throughout the course and that they will be expected to fully participate to help themselves and the learning community succeed (include this in the syllabus as well). Be sure to thoroughly explain each active learning activity when administered.

3) Grade on Participation: Simply showing up might be enough for a purely lecture-based class but it isn't enough when active learning is used. Remind students of the importance of active learning and that they will receive a participation grade for taking part in the active learning event. State that they can also lose points for not being fully engaged in the learning activity. All are needed to help the learning community succeed.

4) Always Have an Instructional Presence: During any active learning event it is imperative that you as the instructor, monitor, modify, and motivate to ensure that the students stay focused (stay on task), understand what they are to do, direct the task so it is as impactful as possible (making modifications when needed) and are encouraged to see the value and importance to the learning activity as well as make important knowledge connections/relationships. Walk around the room and ask questions, if online and broken up into breakout rooms or groups, visit each group to see how they are doing – always have an instructional motivating presence.

5) Invite Questions: An active learning process in itself is to get students to ask questions. Create a learning environment where students know that it is OK and encouraged to ask questions. Lower students' anxiety and resistance by ensuring students know that proper etiquette/netiquette will be used and enforced so questions should be asked and if mistakes, misunderstandings occur, it is OK and will simply help the class learn even more.

6) Solicit Student Feedback: Regularly ask for feedback from students (direct questioning, polling in class, surveys, etc.) to get their thoughts on the activity and to obtain ways in which it might be improved. Also generally observe their level of enjoyment/enthusiasm during the activity. In addition to gaining insights on the activity, this also helps students see that you are working to continually evolve the course to make it the best learning experience possible.

7) Develop a Routine: By implementing active learning from the beginning of the semester, students will start to understand and develop a routine (even if the actual learning activity is different each time). By expecting and knowing that there will be some sort of engaging activity, anxiety/stress about the learning activity will be reduced, and they might even start to look forward to it as well.

8) Use Incremental Steps: In order to help students get better acquainted with the class learning community, the instructor, and the learning topic, easing into more and more advanced active learning activities is generally recommended. This can be viewed as scaffolding, in that you are aiding them in understanding how to conduct active learning, be comfortable with it, and get the most out of it. Preparatory classes/discussions on netiquette/etiquette and procedure may also be helpful.

Active learning has been shown to be an effective way to enhance instructional processes to increase engagement, motivation, and overall learning. Review the implementation techniques described and identify effective ways they can be implemented within your classroom.

References

Anders, B. (2021). *How to be a super student: Based on science and experience*. Sovorel Publishing.

Bloom, B. S. (1956). Taxonomy of educational objectives*. Vol. 1: Cognitive domain*. New York: McKay, 20(24), 1.

Bonwell, C. C., & Eison, J. A. (1991). Active Learning: Creating Excitement in the Classroom. *1991 ASHE-ERIC Higher Education Reports*. ERIC Clearinghouse on Higher Education, The George Washington University, One Dupont Circle, Suite 630, Washington, DC 20036-1183.

Bonwell, C. C. (1996). Enhancing the lecture: Revitalizing a traditional format. TE Sutherland and CC Bonwell (Eds), *Using active learning in college classes: A range of options for faculty*. New Directions for Teaching and Learning no. 67, Jossey-Bass Publishers.

Cashin, W. E. (1985). Improving Lectures. *Idea Paper No. 14.* Manhattan: Kansas State University, Center for Faculty Evaluation and Development.

Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H., and Wenderoth, M.P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences USA 111*, 8410-8415.

Intel. (2021). Active learning fosters technical and innovative learning. Intel Technologies. https://www.intel.com/content/www/us/en/education/teaching-strategy/active-learning.html

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice, 41*(4), 212-218.

Michael, J. (2006). Where's the evidence that active learning works? *Advances in physiology education*, *30* (159 –167).

Pi, Z., & Hong, J. (2016). Learning process and learning outcomes of video podcasts including the instructor and PPT slides: A Chinese case. *Innovations in Education and Teaching International, 53*(2), 135-144.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education* 93(3), 223-231.

Rosario, Z. (2021). An open-source active learning curriculum for data science in engineering. *The Journal of Open Source Education*. 14(46), 117. https://raw.githubusercontent.com/openjournals/jose-papers/jose.00117/jose.00117/10.21105.jose.00117.pdf

Rosenthal, S., & Chung, T. (2020). A data science major: Building skills and confidence. *SIGCSE '20.*

Tharayil, S., Borrego, M., Prince, M., Nguyen, K. A., Shekhar, P., Finelli, C. J., & Waters, C. (2018). Strategies to mitigate student resistance to active learning. *International Journal of STEM Education, 5*(1), 1-16.