Active learning is a teaching method that focuses on student engagement and interaction (Nguyen et al. 2016); it allows students to take their education into their own hands and enables them to “learn how to learn” (Akinoglu and Tandogan 2006). This method often involves student-led classes, where group discussion, presentations, research techniques, and problem-solving exercises are predominant (Dufresne et al. 1996, Allen and Tanner 2005). When active learning is employed in the classroom, there is less focus placed on the instructor, who acts as a facilitator of learning rather than the sole determinant of course content and structure.

In this issue of Best Practices, we will explore different active learning strategies, with a focus on teaching in the sciences.

Is active learning effective in science courses?

Multiple scientific studies have found a statistically significant relationship between active learning and student success. Freeman et al. (2014) performed a meta-analysis examining 225 scientific studies; their goal was to compare traditional teaching to active learning methods in STEM courses and see if there was a difference in examination scores and failure rates between the two techniques. They found that, across all STEM courses, active learning increased overall examination performance and decreased failure rates substantially.

Akinoglu and Tandogan (2006) found similar results when they compared the impact of traditional teaching methods to problem-based learning (a form of active learning). The active learning classes resulted in students having an increased understanding of material (determined through a series of open-ended questions and multiple achievement tests); they also found that students in the active learning treatment felt more confident facing future science courses.

Is active learning difficult to implement in science?

Active learning was developed with small class sizes in mind; however, science classes often have large enrollment and so active learning strategies are not always practical (Allen and Tanner 2005). Additionally, because science classes generally have a strict curriculum, implementing new teaching methods can create extra work for the instructor, including creating new curricula, choosing new textbooks, and dedicating more time to course organization and grading (Dufresne et al. 1996, Allen and Tanner 2005). Finally, some instructors may be reluctant to try new teaching strategies because they fear a negative response from their students (Nguyen et al. 2016).

Implementing active learning in science courses and labs

Although the nature of science courses often makes it difficult to implement active learning strategies, several methods have been developed that lend themselves to teaching in a scientific setting, without requiring extra time and effort.
**Bookending with discussion**

This strategy involves engaging students in class-wide discussions of open-ended questions that are relevant to course material and require a high degree of thinking (Allen and Tanner 2005). It may be structured as a “minute-paper” exercise or a “think-pair-share” activity, but the key idea is to break up lectures and maintain student engagement, ideally with questions at the beginning, middle, and end of lecture (Brickner and Etter 2008). This strategy requires minimal effort in terms of time-commitment and grading, and can be easily employed in large classes.

Yuretich and colleagues (2001) designed a “bookend approach” for their oceanography class, where content was delivered via lecturing for approximately 10 minutes at a time. Between each lecture period, students were provided with relevant questions to discuss in small groups. They were expected to write down their answers and delegate a group member to share their ideas with the class (a version of think-pair-share). Implementation of this method not only fostered collaboration between students, but it also improved attendance, increased exam scores, and enhanced students’ overall interest in science.

**On-the-spot feedback**

This active learning technique can also be effective for large class sizes through the use of technology. The instructor poses a thoughtful question (generally multiple choice) about the course material and gives students time to think and discuss. Each student then sends their answer via some form of classroom response technology to the instructor’s computer, which compiles the answers of all students in the class. The instructor can subsequently reveal the correct answer and show a histogram displaying how the class answered as a whole (Allen and Tanner 2005). This method is effective because it gives students a chance to recall course material, make connections, and immediately determine if they are keeping up with the curriculum (Gasiewski et al. 2012). It also gives the instructor an opportunity to decide if certain topics require more attention.

Dufresne et al. (1996) employed this technique for science students and determined that, in comparison to traditional classroom teaching methods, on-the-spot feedback improved student understanding of subject material and application of concepts. Students also expressed that they felt the class was more enjoyable and more involved; they viewed the instructor as a “coach” rather than a “dispenser of information”.

Logan Newman (2006), a professor at State University of New York, noticed his students were becoming bored and inattentive during his biology lectures, so he implemented multiple “on-the-spot feedback” strategies during his lessons. He first adapted his PowerPoint slides to include fill-in-the-blanks areas so students would subsequently accept responsibility for the information. He also included multiple choice questions following each topic to engage his students and reaffirm their knowledge. These methods fostered participation and discussion during his lectures, improving the overall experience of his students.

**Workshop science**

Workshop science focuses on the idea that science is not simply a static body of knowledge, it involves skills and techniques for effective knowledge acquisition and problem-solving (Udovic 1999). When workshop science is incorporated into the classroom, course activities are often investigative in nature;
students enhance research skills by creating and answering their own questions or developing and sharing opinions on controversial topics (Allen and Tanner 2005).

Udovic and colleagues (2002) have developed several strategies to employ workshop science during lessons, but they all focus on presenting science as inquiry. A specific example involved students choosing an aspect of homeostasis in the body (e.g., temperature, heart rate, etc.). They were then allowed to develop research questions, design an experiment, implement the experiment and obtain results, and finally attempt to persuade their peers to see the validity of their results. This project helped students to appreciate that science is an ever-changing entity, where people must accept differing interpretations of the same information.

Incorporating active learning in the classroom can be a daunting task, but it is entirely worth it for the benefit of so many students from all learning backgrounds. In the sciences, active learning can improve students' academic performance and has potential to enhance students' confidence when facing future STEM courses. The research that has gone into developing active learning strategies for science courses has made it easy and rewarding to introduce active learning to their students, regardless of the structure or constraints of the course.
Work Cited


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