Active Learning Strategies in College Mathematics

James Roy Gatewood

This paper was completed and submitted in partial fulfillment of the Master Teacher Program, a 2-year faculty professional development program conducted by the Center for Faculty Excellence, United States Military Academy, West Point, NY, 2013

Numerous small colleges and universities advertise that they offer small classroom size with good student to instructor ratio, as if proposing that small class size presents a better teaching model than the traditional large lecture hall. Even large institutions describe some instances of the benefits of being at a large institution but with small personalized teaching. However, even in small classrooms if the instructor is teaching in the standard lecture manner, does the classroom environment; whether large or small make a difference in the overall learning of the student?

Instructors teaching by method of lecturing have been the traditional format of college teaching. However, within the last few years there has been some debate on what is the most effective mode of teaching. Many are calling for active learning methods to be used instead of the traditional format (Meyers and Jones, 1996, 6 as cited in Mariya Y. Omelicheva and Olga Avdeyeva, 2008). Critiques argue that lecture based teaching is the transformation of factual knowledge on a topic and doesn’t lead to higher cognitive thought (Anthepohl and Herzig, 1999, Nandi et all 2000 as cited in Mariya Y. Omelicheva and Olga Avdeyeva, 2008). Thus, “Comprehending complex material, for example, requires the ability to connect several components of a phenomenon in a logical and meaningful way. It requires greater student engagement with the material and more “mental energy” that students typically expend in a traditional lecture mode, unless the lecture is accompanied by discussion, short papers, etc. (Renner, 1993; Ruyile 1995, as cited in Mariya Y. Omelicheva and Olga Avdeyeva, 2008).” The
Lecture format is not going away and big class sizes are needed to accommodate large student bodies. However, there are active learning methods that can be used in large classrooms. This paper is an investigation of some of the research put forth about what an active learning environment can resemble in a college mathematics classroom, whether the college course is large or small. Generally we will explore the question, what does an active learning environment look like in a college mathematics classroom and what characteristics do the atmosphere exhibit?

**Active Learning**

Active learning can be described as, “any learning actively engaged in by students in a classroom other than listening passively to an instructors lecture (Faust and Paulson, 1998).” It is the idea that students are fully engaged in learning the material in multiple ways, this includes, “listening practices that help students absorb what they hear, short writing exercises in which students react to lecture material, complex group exercises in which students apply course material to “real life” situations and/or new problems (Faust and Paulson, 1998).” In mathematics, if instructors want students to understand mathematical concepts within the classroom then creating an active learning environment will assist student’s conceptual understanding of mathematical ideas. Otherwise, many students will take down notes but not necessarily engage with the material leading to understanding that is not solid. It is generally agreed upon that the best way to learn mathematics is to actively do mathematics (Rosenthal, 1995). This requires solving problems and discussing them both inside and outside the classroom. Using strategies designed to promote active learning within mathematics can greatly enhance the learning and teaching experience of students and instructors respectively.
Two of the characteristics that take place during active learning sessions are higher order thinking on the students’ part and student motivation increases greatly. If students are actively engaged they are more likely to retain the information they are learning, “the amount of information retained by students’ declines substantially after ten minutes (Thomas, 1972 as cited in Bonwell 1991).” Also, having an active learning environment allows students to be much more interested in the material they are learning and this investment allows students to care more about what they are learning which results in them remembering more (Erickson 1984 pg 51 as cited in Bonwell 1991).

There are four core tenets under the umbrella of active learning; active learning (described above), collaborative learning, cooperative learning and problem based learning. Collaborative learning involves students working together in small groups to accomplish a task (Prince, 2004). They are researching, asking each other questions, collaborative learning emphasizes student learning as a group based activity. Cooperative learning is also a group led activity; however, students will be assessed individually (Millis, B, P. Cottell Jr., 1998, Feden, P, R. Vogel, 2003, as cited in Prince, 2004). Consequently, cooperative learning involves five specific targets, individual accountability, mutual interdependence, face to face promotive interactions, appropriate practice of interpersonal skills and regular self assessment of team functioning (Stahl, R 1994, Slavin, R, 1983 as cited in Prince 2004). The last tenet of active learning is problem based learning. Problem based learning is relevant problems based on the course material is assigned in the beginning of the class period and used for motivation for the current lesson (Prince, 2004).
Though the book, *How Students Learn: History, Mathematics and Science in the Classroom*, was addressing how students learn mathematics at the primary level, it applies to any level of learning mathematics. This book states that learning mathematics proficiently involves,

1. *Conceptual understanding* – comprehension of mathematical concepts, operations, and relations.
3. *Strategic competence* – ability to formulate, represent, and solve mathematical problems.
5. *Productive disposition* – habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy.

We all informally engage in solving mathematical problems at an early stage of our development. However, when presented abstract problems of those learned informally, many students could not solve the problem. Thus a traditional lecture style of teaching might not bridge that gap. If the teaching style is active learning, where students are actively discussing the abstract concepts of mathematics, taking ownership of their learning, they can begin to close the gap between formal training and informal real-world problem-solving experiences (Donovan, Bradsford, 2005).

**Active Learning in Mathematics**

What does active learning look like in mathematics courses whether big or small? Several strategies will be discussed. One such strategy is to personalize the learning experience. Though this study was done in a biology course at the University of Montana (UM) involving 450 students, the principle applied here can also happen in a large mathematics course. To personalize the experience in a large lecture hall, have students write their names on note sheets.
and when they are called upon or want to answer a question an instructor can refer to them by name (Ebert-May, Brewer, Allred, 1997).

Another active learning strategy that can be applied to both large and small classroom settings is to have students work in small groups. Initially in both environments, forming a group might take some time, however, once students get going it is a valuable use of time within the classroom setting. In small groups, students work on solving problems together, asking each other questions and generally discussing the problem. An instructor therefore becomes more of a facilitator, walking around clarifying concepts and encourages students to keep going. This is possible in any size classroom. Applying this method in the lecture hall this automatically made the course more engaging, encouraged more discussion and allowed students to interact with one another (Ebert-May, Brewer, Allred, 1997). As students are engaged in the material, they are learning the concepts, communicating mathematically, and when teaching the material to others they have effectively learned the material. Another benefit of small group exercise is the carry over effect, if students worked together inside the classroom, sometimes this would lead to collaborations and discussions outside the classroom as well (Rosenthal, 1995).

Another active learning strategy which can be applied to both large and small classrooms is to have students write mathematics. Writing is another way to communicate ones’ understanding of mathematical ideas. “Written assignments are known to be a good way to encourage students to think about what they are learning, to remember more, and to see course material in a larger context. They have been advocated across the curriculum including mathematics (Connolly and Vilandi, 1989 as cited in Rosenthal’s 1997).”

Writing helps to solidify concepts. Writing assists students to comprehend and organize their thought process as to what they understand by putting their mathematical ideas into their
own words. “Students increase their ability to communicate about technical matters, an important skill for many jobs (Rosenthal, 1997).” A couple of ways to establish writing in a college math course is the minute paper at the end of the class and explanation of solving problems. The minute paper at the end of class involves students writing down what they understood from the class that day as well as what they did not understand. These assist students in understanding were they have strong understanding and weak areas. Another writing strategy is for students to describe how they would solve a particular problem in words. Again, this writing process requires students to reflect their own thought process and think through a math problem (Rosenthal, 1997).

**Conclusion**

Creating an active learning environment in a mathematics course might take more work on the instructor side to be creative on how to present mathematical concepts. However, one of our goals to teach mathematics is to present the material in an engaging way to make it accessible to as many students as possible. Also, with the understanding that active learning leads to more engaged students and we know that one learns mathematics by doing mathematics; our environments should be pushing active learning strategies whether in big or small classroom environments.

**References**