

Active Learning Through Teaching in an Extracellular Matrix Engineering Course for Biomedical Engineering Graduate Students

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Abstract

Engineering education cannot be successful by focusing on teaching content alone. Future engineering leaders require both a broad knowledge base and effective communication skills. This study examines both the attitudes engineering graduate students have about effective teaching and learning practices as well as the influence of teaching as an active learning strategy on those attitudes. A new disciplinary course was developed for students to enhance their understanding of extracellular matrix engineering (ECM) and introduce them to active learning as a pedagogical approach. Student attitudes were assessed quantitatively through pre and post course surveys, and qualitatively through discussion about pedagogical approaches after each lecture. We show results indicating that this class format improved students' confidence in ECM knowledge, as well as their confidence in leading discussions; student presentation skills also improved. These results demonstrate the efficacy of using teaching as tool to both engage students in active learning and teach them about the approach to ultimately create diverse learning environments in classrooms and more effectively educate the engineering professional of the future.

Introduction

It has been well established that to function more effectively in the "knowledge age," learners must become self-regulated and capable of assimilating and accommodating new knowledge (Schunk & Zimmerman, 1994). The term active learning is commonly used to describe teaching techniques that stress students' active involvement in their own learning. Active learning can be used to not only help students move beyond surface declarative knowledge of their discipline and to develop a deeper conceptual understanding, but can also be a tool to develop a student's ability to teach themselves and their peers new concepts. Research on the benefits of active learning demonstrates that in addition to achieving learning objectives related to content, students can develop abilities in communication, leadership, ethical decision making, and critical thinking (Hake, 1998).

Interestingly, active learning has the power to strongly polarize students and faculty alike. There are many strong advocates among faculty looking for alternatives to traditional teaching methods; however, there are also many skeptical faculty members who feel active learning is another in a long line of educational fads (Prince, 2004). It is not only faculty members that are

at odds. Many students find that they learn more and are able to hold on to the knowledge longer when material is presented in an active learning format (Ruhl, Hughes and Scholoss,1987). On the other hand, many classes are still taught in a purely lecture format, and those students who find themselves rising to the top of their classes and pursuing graduate studies are often the students who prefer lecture format classes and feel that they learn well that way. The problem arises in that these students are the future educators and faculty members who will be teaching classes to students of all learning styles, not just those for which a lecture based format works well.

With this in mind, we chose to plan a disciplinary class in which we examined graduate student attitudes about effective teaching and learning practices. We also sought to determine the influence that teaching, as an active learning strategy that both engaged students in active learning and taught them about the approach, had on those attitudes. In this paper, we describe graduate students' adoption of active learning through teaching in Extracellular Matrix Engineering, a biomedical engineering class for graduate students. We identify barriers to implementing active learning in the classroom, changes in student attitudes about active learning, and results that speak to the efficacy of using teaching to promote active learning in a graduate level course as a way to more effectively educate the engineering professional of the future.

Class Design

During the spring semester, 2008, eleven first through fifth year graduate students in biomedical engineering were engaged in active learning through teaching a topic and presenting a journal article related to extracellular matrix engineering. Students' active involvement in the course was twofold. By leading a lecture, each student was involved in the process of deciding what to cover as well as how to cover it; incorporating active learning techniques in their lecture gave students an opportunity to practice the approach themselves. Secondly, participating in journal discussions as a leader and a participant allowed students to practice active learning techniques outside of the lecture framework. All students played the role of both teacher and learner throughout the semester.

In the teaching component, students were asked to incorporate a technique to engage their classmates in an exploration of the topic. This could include, but was not limited to, brainstorming, case studies, class polling, pre/post questions, concept mapping or think-pair-share (Handelsman, Miller and Pfund, 2007). Each student was also asked to develop questions about the topic. These questions were intended to cover what the student considered the "take home message" of the lecture. Question preparation was intended to help student instructors organize their lecture with the goal of covering those main points. It was also used as a technique to help gauge what the students in the classroom were taking away and learning from lecture. All students were asked to hand in the answers to the questions after class.

The literature learning portion of the class involved a student-led discussion of a journal article. Everyone in the class was responsible for reading the paper ahead of time; however, the student leader was required to give an introduction and some background to the paper, its context within the literature and an explanation of any unusual or new methods used in the paper. The student leader was then to assign the remaining students to groups to present each figure. The leader

facilitated class discussion with planned questions that were handed out before class. At the end, the leader summarized the conclusions of the paper and addressed the paper's contribution to the advancement of the field.

The first lecture was led by the professor and demonstrated an outline of how material should be covered. An example of concept mapping was incorporated into the lecture to demonstrate an active learning technique. The first literature learning activity was also instructor led to demonstrate the expectations and flow of the activity. Active learning was introduced to the students through a hand out that was developed from Handelsman, Miller and Pfund, 2007, as well as through a presentation about active learning/engaging techniques they could employ in their lectures. Additional support was given to the students throughout the semester by the instructors to help them develop their lectures both from a content perspective and an active learning perspective. For the latter, students were asked to come in and speak with one of the instructors about what technique they planned to use and how they would implement it. Additionally a class discussion was held after each lecture to discuss what went well in the active learning activity and what could have been improved.

Results

Attitudes were assessed in three ways. Quantitative assessment was completed through pre- and post-course surveys. These were used to gauge a range of topics including: students' teaching experience, confidence level in teaching, and opinions about teaching practices, including active learning techniques (Appendix A, questions 1-6). The post survey also addressed students' feelings after taking the class (Appendix A, question 7). In addition, attitudes were addressed qualitatively through instructor-led discussion after each lecture about what worked well and what did not in terms of pedagogy used.

In both the pre- and post-surveys, (Appendix A, question 2), students were asked to rate their confidence about various aspects of the course. Students reported being more confident leading a discussion after completing the class. An improved confidence level of extracellular matrix knowledge was also observed. A slight increase in confidence toward presenting a lecture or using new teaching techniques was observed, but these were not statistically significant.

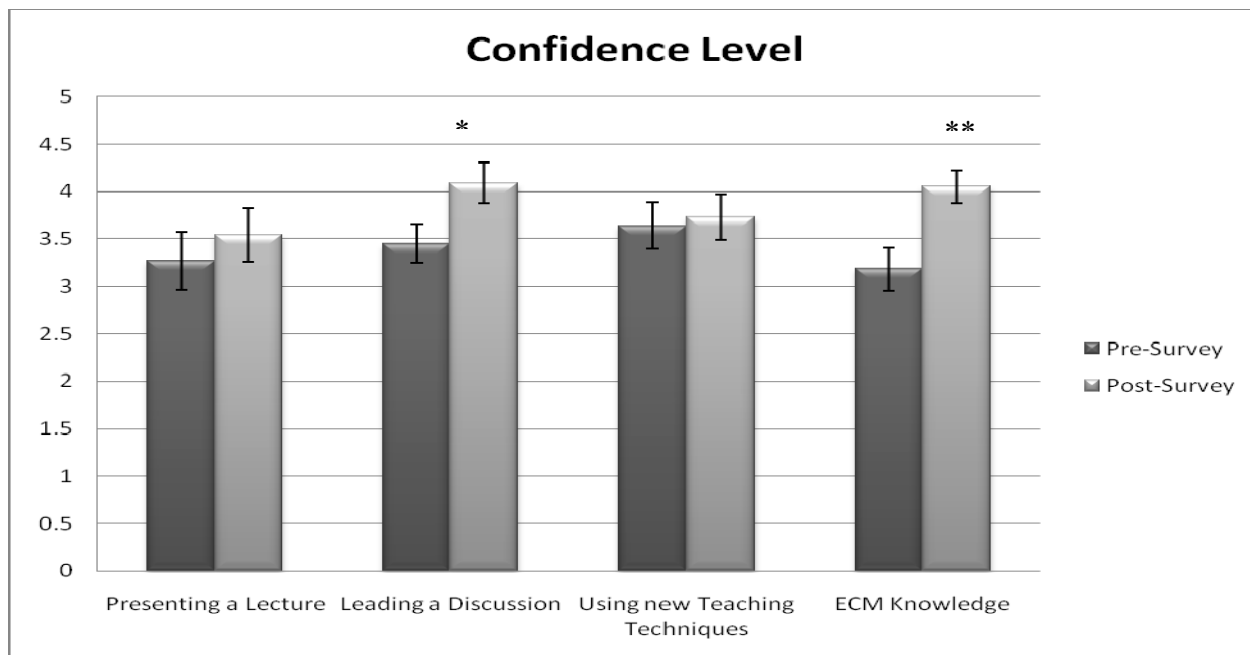


Figure 1. Student confidence increases for both teaching skills and ECM content knowledge. Students ranked their confidence on a scale of apprehensive (1) to very confident (5). Paired students' t test was used to compare pre- and post-survey results. *Indicates significant at .05 and ** indicates significant at .01.

In the pre- and post-survey students were asked to list the steps that they would go through if they were preparing a lecture. After preparing a lecture, leading a class discussion and talking about teaching throughout the semester, students' approaches to planning a lecture became more developed and specific. Six out of eleven students increased the number of steps that they would go through to prepare a lecture. Additional steps that were added included planning an active learning component (added by 27% of students in the class), practice (added by 18%) and development of learning goals around which to organize a lecture (added by 45%, Appendix A question 3).

When examining the likelihood of students to use different active learning techniques in their own classroom (Figure 2), there was a trend for students to be more likely to want to try teaching techniques that were used frequently and well demonstrated in the course (i.e. Case Studies, Brain Storming, and Think-Pair-Share).

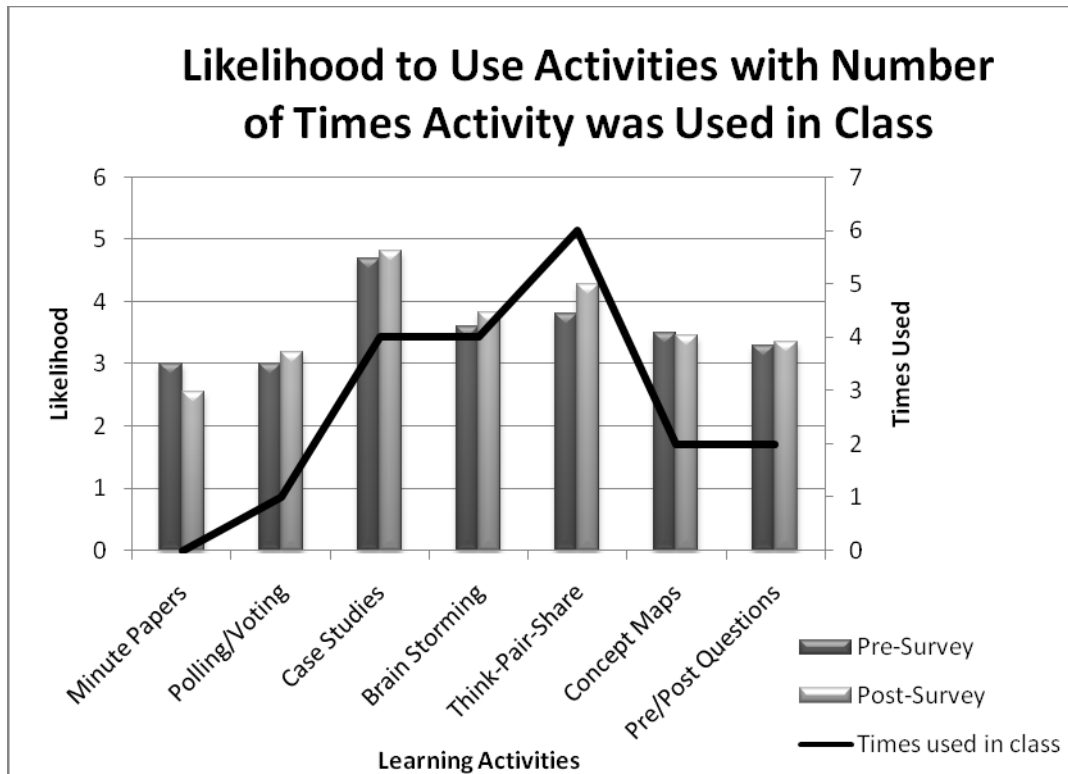


Figure 2. Students were more likely to use certain learning activities when they were demonstrated often in class. Students ranked the likelihood they would use active learning techniques on a scale of unlikely (1) to very likely (5).

Some differences in survey answers between students with teaching assistant experience and those students who had no teaching experience were noted. Students who came primed through previous teaching experience were in strong agreement that active learning was helpful in understanding course material and gave an average score of 5 (strongly agree), as opposed to those with no teaching experience who gave an average score of 3.29 (neutral) at the end of the class. This was the only significant parameter in the teaching experience subgroup with a p value of .01. Both instructors observed that students who had teaching experience were more interested in learning new teaching techniques, more willing to meet and talk about their teaching and had an easier time incorporating and executing active learning approaches in their lectures.

When asked the degree to which they agreed or disagreed with the statement “I do not feel that I improved my presentation skills in this class,” students disagreed with an average rank of 2.27. This indicates that even though students with previous teaching experience were more comfortable using active learning techniques, most students did feel that they improved their presentation skills in the class. Additionally, both oral and visual presentation skills improved based upon evaluation by the instructors.

Students’ opinions about receiving input about their teaching and studying their effectiveness in the classroom were high both before and after taking the class. Specifically, students on average

ranked these points between agree (4) and strongly agree (5) both before and after the class (Appendix A question 6).

Examining students' depth of discussion around active learning as a teaching approach, it is clear that there is an increase in confidence as well as ability to discuss active learning techniques. For example, when discussing the effectiveness of techniques demonstrated in class, during the first few weeks of class students were quiet and would simply say their classmates did a "good job." Later, discussions became more complex and included misconceptions that were brought to light because of the active learning activity. The concepts of having a learning goal for the active learning activity and making the activity difficult enough to encourage group work were frequently discussed as important in the second half of the semester. Students claimed to like the creativity encouraged by active learning activities and commented that the activities helped them to "think." At the end of the class three main points emerged as being very important in a successful active learning component: confident execution, clarity and level of difficulty.

Discussion

The goal of this class was to create an inclusive group of students and instructors that assisted collaborative and active learning while addressing disciplinary knowledge of the extracellular matrix. Because all members of the class were responsible for developing and giving a lecture in which they tried active learning techniques as well as leading a literature learning discussion, they all shared the responsibility for the learning that took place during the class. They did not rely on traditional "expert centered" lecture formats. Through the preparation of questions about their own lecture, the students could see how well their peers learned as a result of the teaching approach they used. Students came to understand that if they were going to learn the material shared responsibility and collaboration were necessary.

As a result of teaching this class, there are several modifications we believe would make this a more productive learning experience. For example, one-on-one meetings with the instructor to discuss choice and execution of active learning activities were implemented after the first two students experienced difficulty implementing the component. The first student to lecture chose not to incorporate an active learning component at all. It is now clear that these meetings should commence at the onset of the class. Additionally, students held a range of attitudes toward active learning from positive to very negative. By the end of this class, a few students still felt very strongly that they did not learn better with active learning. An open discussion about these attitudes at the very beginning of class may have been helpful. Instructor attitude and action throughout the class is also important. Both instructors admitted reservations about active learning in the first few class periods to try to connect with apprehensive students, but this just seemed to justify students' dislike of active learning, thereby shutting them down to new ideas and concepts from the beginning.

The significant increase in students' confidence in leading discussions and confidence in knowledge of the ECM indicates that teaching as an active learning method is successful not only in improving aspects of presenting, but also can improve students comfort level with contextual knowledge. Additionally, the students' complexity of planning a lecture increased after taking the class, suggesting the class activities helped students to better form ideas on how

to prepare a lecture including adding an active learning component as well as organizing a lecture around learning goals. In general, students were more likely to want to try teaching techniques that were used frequently and were well demonstrated in the course. One student even noted on the post-survey a particular experience in the class in which they “learned extremely well.” This particular experience was a student led think-pair-share activity on the board explaining how to graph stress vs. strain of a fiber. This activity was clearly introduced, led with confidence and was difficult enough to engage students and encourage cooperative work. It was a very good example of active learning working well, and students recognized it as such.

In general, students had a positive attitude about getting input from peers and colleagues about their teaching as well as getting feedback from their students about their teaching both before and after the course. This course did not seem to impact their attitudes much on these issues, but because their interest was so high in the pre-survey it would be hard to see an improvement. However, this course format did improve students’ presentation skills as determined by the instructor as well as how students felt about their presentation skills. Because confidence was determined to be a major factor in successful execution, this is particularly important.

There were some differences on how students replied on the survey. Students who had classroom experience were more likely to be receptive to the active learning activities in this course. We believe it may be because these students are looking for tools to improve their ability to communicate ideas in a classroom. On the other hand, students with no classroom experience were perhaps unaware of some challenges of conveying information in a classroom setting making them less receptive to active learning ideas.

Discussion was a very important part of this course. As the course continued throughout the semester, discussion helped to identify and solidify what makes an active learning activity work well in a class room, particularly the three main points identified in the results section: confident execution, clarity and difficulty level. Overall, discussion became more in depth throughout the course and allowed people to address their own reservations about active learning. This was definitely a key component in helping this class work, and some of the negative feelings toward active learning could have been brought out more in these discussions.

As a whole, this course was successful in helping to raise the awareness and understanding of active learning teaching techniques. Students typically clarified their feelings about active learning techniques and were able to try different teaching techniques in a safe environment with their peers. This in turn improved their confidence level in classroom components such as leading a discussion as well as confidence of the contextual knowledge of the course. This is a very important step in developing effective communicators and educators in the engineering field of the future. Using teaching as an active learning component to educate graduate students may be an important step towards generating a more diverse learning environment and an improved engineering classroom in the future.

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Biographical Information

Elizabeth McNeill is a Ph.D. student in the department of Nutritional Sciences at the University of Wisconsin, Madison. She is planning on completing her Ph.D. May of 2009 and completed this work as part of a Delta Internship project a component of the Delta research teaching and learning certificate.

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Appendix A

Teaching and Learning Questionnaire

1. While in your current graduate program, did you ever hold a teaching assistantship or graduate student instructor position? (Specify which)

2. Indicate how do you feel about:

1 Apprehensive 2 Somewhat apprehensive 3 Neutral 4 Somewhat confident 5 Very confident

Presenting a lecture 1 2 3 4 5

Leading a discussion 1 2 3 4 5

Using new teaching techniques 1 2 3 4 5

Your knowledge level of the Extracellular Matrix 1 2 3 4 5

3. If you were preparing a lecture, list the steps that you would go through.

4. How likely would you be to use the following teaching techniques in your own classroom?

1 Unlikely 2 Somewhat unlikely 3 Neutral 4 Somewhat likely 5 Very likely

Minute papers (write a short answer about a topic or question) 1 2 3 4 5

Polling/Voting on review questions during class 1 2 3 4 5

Case Studies (solve a problem or situation in a real world context) 1 2 3 4 5

Brainstorming (list as many answers as possible to a question) 1 2 3 4 5

Think-Pair-Share (think about a problem individually, discuss
with a partner and come to a consensus) 1 2 3 4 5

Concept maps (arrange a series of events into the correct order) 1 2 3 4 5

Pre/post questions (answer before and after a topic is taught) 1 2 3 4 5

5. Describe an experience you have had in a classroom where you feel that you learned well.

Think-Pair-Share	3.8	4.27
Concept maps	3.5	3.45
Pre/post questions	3.3	3.36
5. Answers varied by students		
6. Statements	Pre-	Post-
Input from others	4.7	4.73
Study of instructional practices	4.3	4.55
Interdepartmental advice	3.9	4.09
Study of learning	4.7	4.73
7. Statements		Post-
Active learning helps understanding		3.91
Presentation Skills not improved		2.27