Connecting with Students in Large Classrooms

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Abstract

Nationwide engineering enrollment has increased by more than 50% in the last ten years, while the number of tenured/tenure-track faculty has increased by only 15% over the same time period. One result of this trend is an increase in the size of engineering classes, and the concurrent need to be able to connect with students in these large classes. This paper addresses this important issue by reviewing some of the techniques for connecting with students that have been reported by other engineering educators, followed by a review of the discussion and suggestions from a recent seminar/discussion held on this topic at the University of Arkansas (U of A). While the literature suggests that better classroom organization is effective in reaching students, educators must also realize that many different learning styles and preferences are represented by the students in our classes. Centering the class on an advanced technology or a theme, such as a plant trip or life cycle assessment, can help us better reach the students. However, sometimes the little things—getting to know the students, providing time for interaction or engaging the students—can also help us make valuable learning connections.

Introduction

The Bureau of Labor Statistics (2018) notes that employment for architects and engineers is expected to grow by 7% in the next ten years, with the addition of about 194,300 new jobs. Engineers will be in demand in areas such as the rebuilding of infrastructure, renewable energy, oil and gas extraction, and robotics. Universities have answered this call for engineers by enrolling more students and graduating more engineers. Figure 1 shows the nationwide trends in the enrollment of undergraduate engineering students and the number of B.S. engineering graduates from data compiled by Yoder (2016), and Figure 2 shows the nationwide trends in engineering faculty numbers and the ratio of enrolled undergraduate students per tenured/tenure-track faculty, also from data compiled by Yoder (2009-2016). Both the enrollment of engineering students and the number of engineering graduates have increased by more than 50% over the last ten years. Concurrent increases in engineering faculty numbers have not been as dramatic, showing only a 15% increase in the number of tenured and tenure-track engineering faculty since 2009. In fact, the engineering enrollment per faculty member has increased from 18.9 students per tenured/tenure-track faculty member in 2009 to 23.4 students per faculty member in 2016. The use of nontenure-track teaching faculty has helped to alleviate some of this teaching burden, but nontenure-track faculty are yet not being used as extensively in engineering when compared to other academic programs.

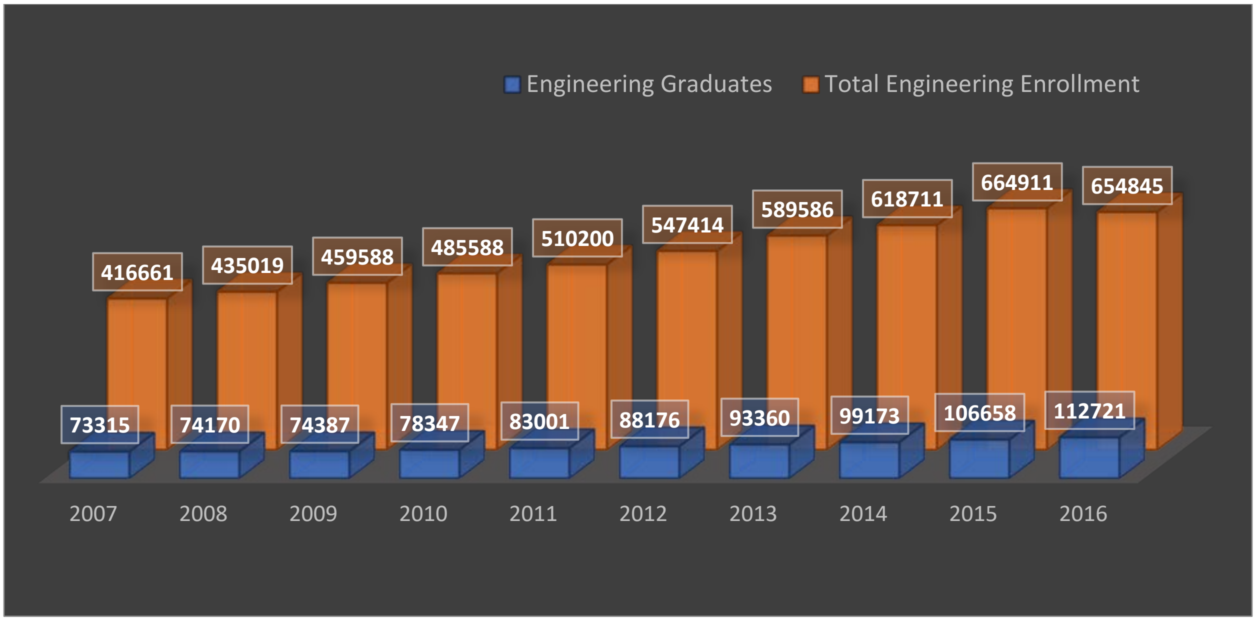

Figure 1. Nationwide Trends in Undergraduate Engineering Enrollment and B.S. Engineering Graduates (data from Yoder 2016)

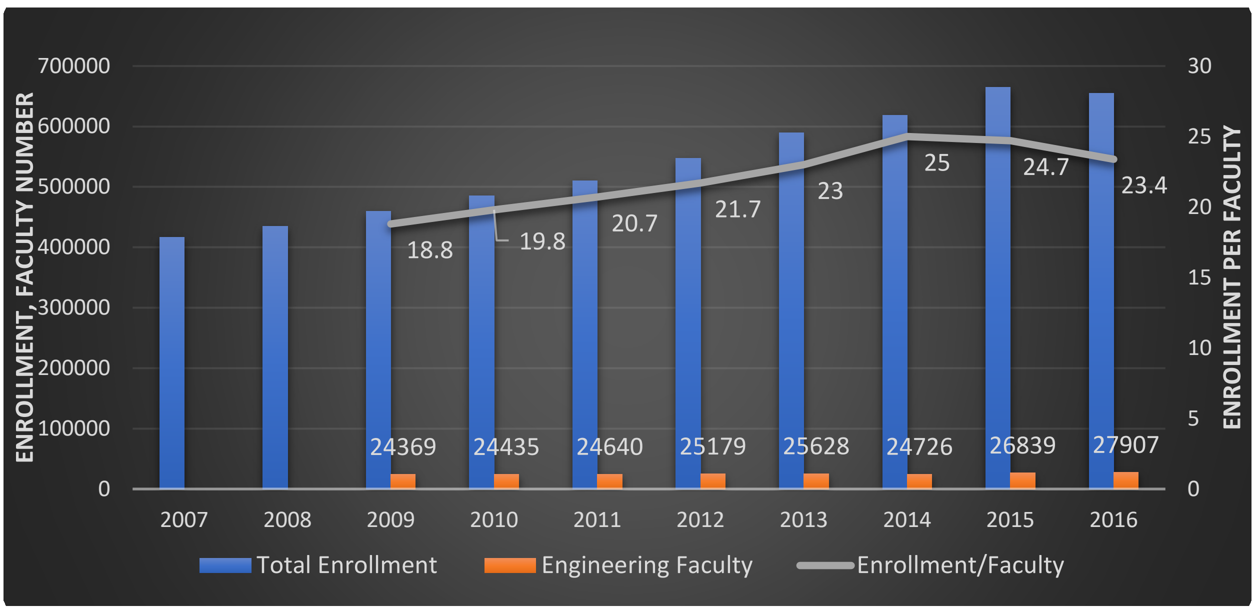

Figure 2. Nationwide Trends in Tenured/Tenure-Track Faculty with Engineering Enrollment (data from Yoder 2009-2016)

Even more dramatic results are noted when moving closer to home. Figure 3 shows trends in the enrollment of engineering students and the number of engineering graduates at the University of Arkansas (U of A) from data compiled by the its Office of Institutional Research and Assessment (2018). Figure 4 shows the trends in the number of engineering faculty at the U of A, as compiled in the College of Engineering Fact Book (2016), and the engineering enrollment per tenured/tenure-track faculty. As is noted in Figure 3, engineering enrollment at the U of A has more than doubled over the last ten years, while the number of engineering graduates has increased by 130% over the same period. Figure 4 shows that the number of engineering faculty at the University of Arkansas has increased by only 7% over the last six years and the engineering enrollment per faculty member has increased from 22.3 students per tenured/tenure-track faculty member in 2011 to 30.0 students per faculty member in 2016.

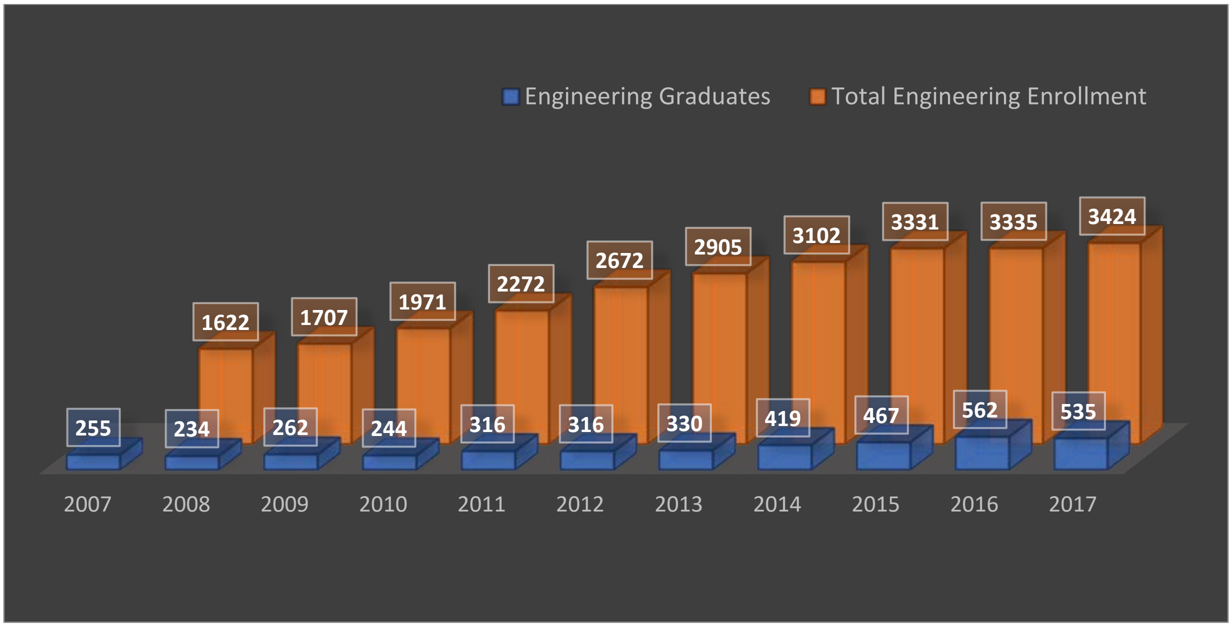

Figure 3. Trends in U of A Undergraduate Engineering Enrollment and B.S. Engineering Graduates (data from U of A Office of Institutional Research and Assessment 2018)

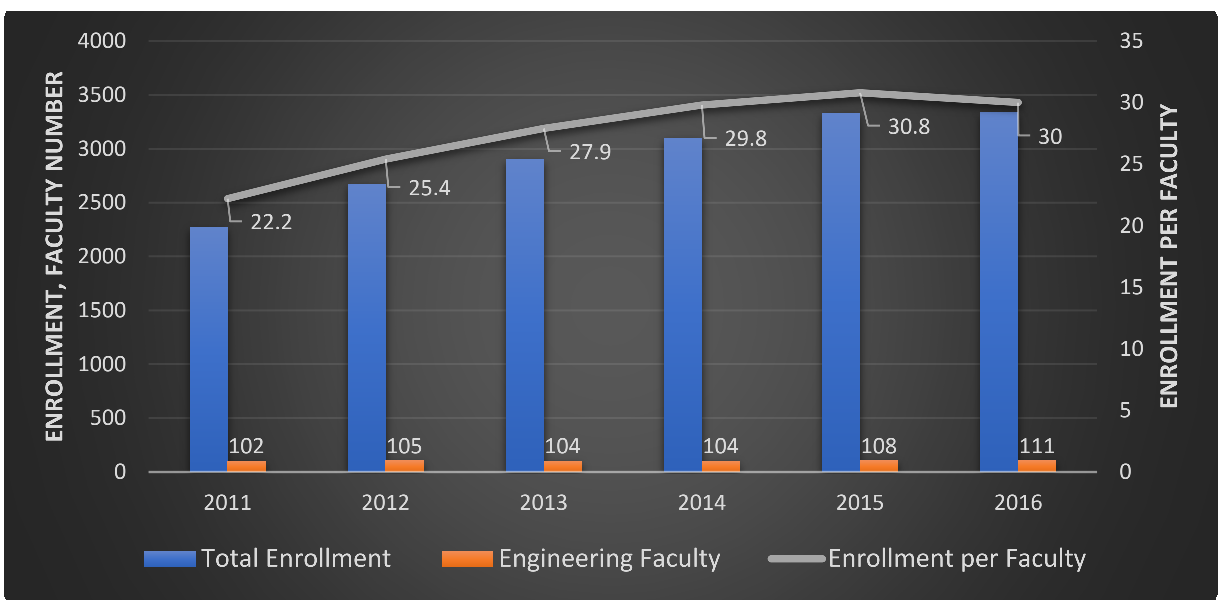

Figure 4. Trends in U of A Tenured/Tenure-Track Faculty with Engineering Enrollment (data from College of Engineering Fact Book 2016)

The effect of these trends on class size is illustrated as a simple example in Table 1, where class size in CHEG 2113, Introduction to Chemical Engineering, at the U of A is shown for each school year, beginning in 2007-2008 and ending in 2017-2018. The class was taught using only one section per semester. An upward trend in class enrollment was observed from Fall 2007-Fall 2011, when it was decided to offer the class in both academic semesters to somewhat limit class size. The upward trend in *potential* class size (that is, if the class were not offered in both semesters) is noted in the last column of the table, which regularly shows a *potential* class size of more than 100 students and as high as 121 students in 2015-2016.

Table 1. Enrollment in CHEG 2113, Introduction to Chemical Engineering, at the U of A, 2007-2018

School Year	Semester	Class Enrollment	Class Enrollment For School Year
2007-2008	Fall 2007	47	47
2008-2009	Fall 2008	45	45
2009-2010	Fall 2009	55	55
2010-2011	Fall 2010	75	75
2011-2012	Fall 2011	69	69
2012-2013	Fall 2012	80	96
	Spring 2013	16	
2013-2014	Fall 2013	69	94
	Spring 2014	25	
2014-2015	Fall 2014	80	117
	Spring 2015	37	
2015-2016	Fall 2015	83	121
	Spring 2016	38	
2016-2017	Fall 2016	68	95
	Spring 2017	27	
2017-2018	Fall 2017	73	100
	Spring 2018	27	

Chemical Engineering classes are far from being the largest classes on campus. Table 2 shows class enrollments for selected "large" science and engineering classes at the U of A for the Spring 2018 and Fall 2018 semesters. While large engineering classes may have 100-200 students, some of the lower level science classes can have enrollments exceeding 400 students.

Table 2. Enrollment in Selected "Large" Classes at the U of A, Spring 2018 and Fall 2018

Spring 2018		Fall 2018 (projected)	
Class	Enrollment	Class	Enrollment
BIOL 2013, Microbiology	475	BIOL 2013, Microbiology	453
BIOL 1543, Biology	381, 314	BIOL 1543, Biology	300-468
PHYS 2074, Physics II	265, 220	CHEM 1103, Chemistry I	215-265
CSCE 2014, Programming II	164	PHYS 2054/2054H, Physics I	280, 361
CHEG 4423, Process Control	102	CSCE 2004, Programming I	121

MEEG 2013, Dynamics	95	MEEG 2003, Statics	174

There are developing problems in engineering education that are at least partially associated with these enrollment trends, including:

- Poorer instructional quality. Many faculty have become increasingly more interested in research and thereby less interested in teaching and laboratory instruction. As enrollments have increased, some faculty have turned away from detailed problem solving to easier ways to assess student performance. Finally, many faculty expect less from their students while, at the same time, continuing to inflate grades.
- Less prepared engineering graduates. Poorer quality of instruction and lowered faculty expectations, coupled with an observation that fewer students are entering the university with hands-on experience, may result in a larger number of graduates that are not well prepared upon entering the workplace.

While one might argue that these problems are not widespread, one thing is very clear: the increased enrollment and graduation trends coupled with minimal increases in engineering faculty produces larger and larger classes which, by itself, detracts from student learning. So, how can we, as engineering educators, more effectively reach students in large classrooms? The purpose of this paper is to address this important question by first reviewing some of the techniques reported by other engineering educators, and then to report on some of the informal discussions and suggestions from a recent seminar/discussion held on this topic at the U of A.

Classroom Effectiveness

Felder and Brent (2005) remind us that the students in our classrooms can be quite different. They can differ in what motivates them and how much they are motivated, they can have different attitudes and preferences in how they are taught, and they can respond differently to alternative teaching styles and practices. While learning has a lot to do with the individual student's ability and prior preparation, learning is also affected by the instructor's teaching style and the compatibility of the student to that style. Lumsdaine and Lumsdaine (1995) note that there has been a shift away from "plug-and-chug" thinkers to more creative thinkers, but that students generally prefer to avoid teamwork activities. Ing and Victorino (2016) note that there are noted differences in classroom engagement among Asian American populations.

Problems solving is an essential tenet of engineering education. McNeill *et al.* (2016) note that engineering students have different beliefs about problem solving and draw a sharp distinction between problems presented in the classroom and problems found in the workplace. This belief system affects the ways students approach problems and once again underscores that not all students learn alike. In addition, students have different attitudes about collaborative learning. Stump *et al*. (2011) note that students perform better when working with peers on assignments and in discussing course material. However, they also reported that female students were more likely to collaborate than their male counterparts. Lin and Tsai (2009) noted, in a survey of 321 undergraduate engineering students, that just under half of the of the students preferred classroom instruction (calculating, practicing and testing) to laboratory instruction (increasing their knowledge base, applying and understanding).

Despite these differences in our student population, there have been many efforts to better connect with students in the classroom. Internet and network instruction has been one popular choice (Wallace and Mutooni 1997; Kashy *et al.* 1998; Wallace and Weiner 1998; Latchman and Latchman 2000; Dutton *et al.* 2001). Of particular interest is the use of networked tools in a 500-student calculus-based physics course for engineers, where networked systems were used to generate personalized assignments, provide on-line assistance and provide rapid feedback on assignments and exams (Kashy *et al.* 1998). This on-line approach led to an 18% increase in student success and a small but significant decrease in the dropout rate. Dutton *et al.* (2001) compared the performance of students who took a programming class face-to-face vs. students who took the class through on-line delivery. The on-line students performed significantly better in the course but were also found to be less likely to complete the class. Griffioen *et al.* (1999) discussed the use of a wireless classroom which supports a teaching style that is a mixture of lecture, student-teacher interaction and student problem solving. The authors indicated that the positive aspects of this interactive classroom alternative outweighed the technical challenges of the delivery method.

A number of other techniques for developing better student-faculty interaction have been tried with mixed success including the incorporation of life cycle assessment into early engineering classes (Weber *et al.* 2014); the use of incidental writing, or informal writing that students do throughout the course (Hawkins *et al.* 1996); using a plant trip as a theme for an energy balance course (Younf and Stuart 2000); integrating thermal-fluid experiments into the classroom (Olinger and Hermanson 2002) and using problem based learning in an electrical engineering course (Yadav *et al.* 2011). Finelli *et al.* (2001) present a list of activities that might improve the classroom environment, taken from a roundtable discussion at the 29th Annual IEEE/ASEE Frontiers in Engineering Conference. These suggestions for improvement, categorized as suggestions for planning the course and suggestions for conducting the course, are summarized in Table 3. Along these same lines, Smith *et al.* (2005) outlined the pedagogies of successful classroom engagement, particularly for cooperative and problem-based learning. Finally, Gall *et al.* (2003) noted the importance of instructor accessibility to the classroom environment and, as a bonus, as an important factor in obtaining good instructor ratings by the students.

Table 3. Suggestions for Improving the Classroom Environment (from Finelli *et al.* 2001)

Planning the Course
Prepare a set of instructional outcomes
Develop a syllabus to communicate course goals
Establish a clear policy that is consistent with the instructional objectives
Provide feedback about students' performance with respect to grading policy
Conducting the Course
Plan a productive first class session, describing the relevancy of the course
Establish ample office hours, and be available for them
Respect students' time in the classroom
Distribute copies of key theory, leaving gaps for students to complete
Utilize alternative methods for delivering course material
Set realistic expectations for students and encourage questions
Face the student audience, and speak slowly and clearly
Assess the progress of the course throughout the semester

Periodically update course content to reflect evolving technology
Relate curriculum to real life problems and to current events
Draw on personal experience and use student examples for practical applications
Provide suitable activities that appeal to each learning style
Understand personal learning style
Encourage class participation
Use active or cooperative learning after careful planning

Reaching Students in Large Classes: A Seminar/Discussion

In February, 2018, U of A faculty gathered for a seminar/discussion on how to better reach students in larger classes, sponsored by the U of A Teaching Support Center. The format for the event was a short presentation by the moderator, the lead author in this paper, followed by an open discussion of teaching techniques employed by the other faculty in attendance. Approximately 30 faculty attended the event from the College of Engineering and other colleges across campus.

What is a Large Class?

Because of the relative sizes of academic colleges (large colleges of Arts and Science and Business vs. relatively small colleges of Engineering or Agriculture, for example) and the differences in the content that is taught (facts, problem solving, discussion), the definition of a large class varies rather widely across campus. Of course, smaller colleges and universities will typically have smaller classes, and universities with a significant research mission will typically have larger classes. Table 2 previously showed enrollments in a few of the larger U of A science and engineering classes and enrollments during the Spring 2018 and Fall 2018 semesters. Science classes, as well as classes from other disciplines outside of engineering, can be quite large, while the Engineering classes are smaller, but large compared to 10-20 years ago. This perspective is useful because techniques that engage students in one class may or may not work in another because of class size, delivery style and content.

What Has the Moderator Done to Engage Students?

To begin the session, the moderator noted that he had three basic premises in engaging students in the classroom, regardless of class size:

- The students need to feel comfortable with the instructor, both in and outside of the classroom
- Students need to interact with their fellow students and the instructor as part of the classroom experience
- These ideas are fostered through communication, both in and outside of the classroom

He then spoke of some of his favorite ways of engaging students, which are briefly described below.

Ice Breaker for the First Day of Class. A modified version of the Shoe Pile Mingle (Howstuffworks 2018), a somewhat disgusting icebreaker that requires students to form a pile of shoes and then find the owner of one of the shoes, has been used as a way for students to meet others in the classroom. In the modified activity, the students are first directed to find someone that is different than you (no shoes involved) but are given no further direction. The pair of students then discusses some of the things that they have in common. The pair introduces each other to the class, noting something they have in common. Groups of four are formed by combining two pairs of students—these are initial working groups for future class activities. This activity is particularly useful in introductory classes, where students have likely not met each other previously.

Build a Scorpion. In an effort to foster communication, the students can be given the necessary supplies to construct a scorpion from PVC tubing, shown in Figure 5. The students are simply shown a completed scorpion and then given the tubing, fittings, a ruler and a tubing cutter to build a scorpion during the next class period. Glue was one of the supplies items in an early iteration of this activity, but it was soon realized that messy glue is really not needed. Groups from the icebreaker are typically used for this activity. The major problem with this activity is that it costs about $200 for 80 students, although the tubing cutters (the most expensive item) can be used in subsequent semesters. During the spring 2018 semester, the students were encouraged to use their design skills to construct other animals. Figure 6 shows that the students also made giraffes, butterflies, ducks and super scorpions.

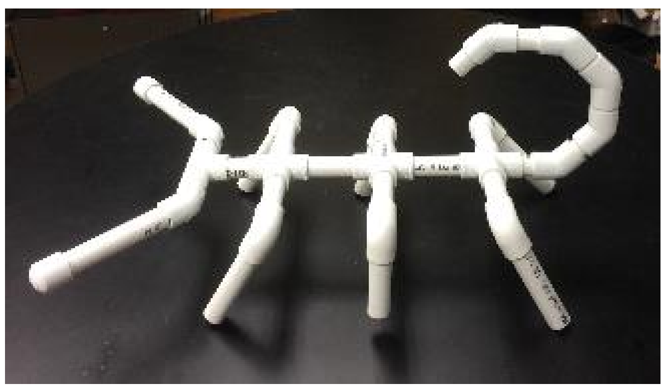

Figure 5. Build a Scorpion

The Homework Table. In using the homework table, students are invited to come to the instructor's office at any time to view the instructor's solutions to homework assignments that are left on the homework table (see Figure 7). Students use this table in several ways: to check their answers, to just copy the homework (without understanding) and to understand the instructor's solution while soliciting help. The key to the success of this table is that the instructor is usually in his/her office when the students arrive, and the instructor can then use the homework as a vehicle to get to know the student and to provide help on the homework outside of the classroom.

Figure 6. Student Creations, in Lieu of the Scorpion

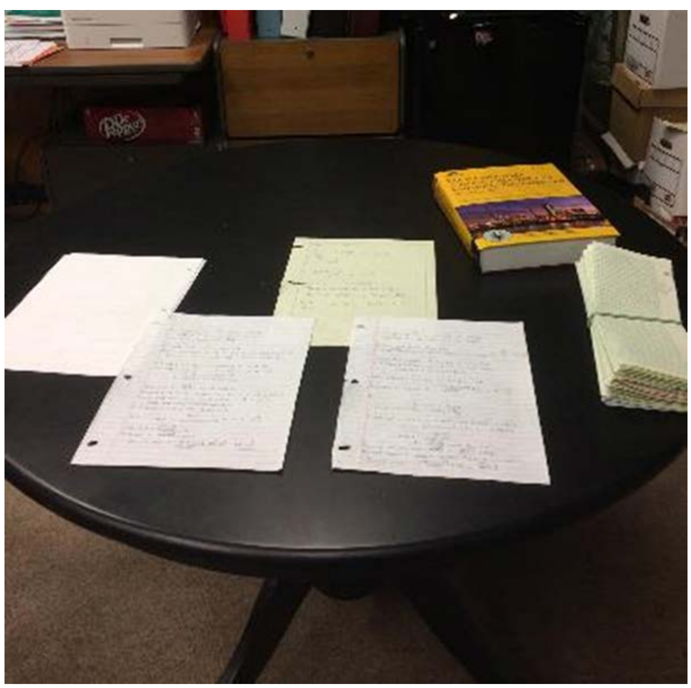

Figure 7. The Homework Table

Pause for a Story. Have you ever seen that glossed over look or the look of total boredom from several members of your class? Perhaps it is time for a story (from your past career or time as a student). Of course, the stories need to be entertaining. An alternative is just to ask the class how the local sports team will do in the next ballgame. These short breaks usually work to wake up the class and the instructor can return to class content in a short period of time.

Review Day Before Exams. In employing a review day before exams, the students are first given an old exam (with answers, but not the solution) two class periods before the exam. The class period before each exam is then reserved for review—some people work on the old exam, some don't show and some show, but are lost. This is a good time for one-on-one interaction, particularly to get the lost students back on track.

Audience Participation

After the brief presentation by the moderator, the audience was invited to briefly describe some of their own techniques for engaging students in the classroom. A listing of some of these ideas is presented in Table 4. Lots of good ideas! What works for you?

Table 4. Techniques for Engaging Students, as presented by the Audience

Learn the names of the students and something about them, or at least those who are actively engaged in the course (in a 400+ course it may not be possible to learn ALL of their names!). This gives some accountability or a sense of accountability to the students. Walk around the classroom, especially in a large lecture room. Use a microphone and walk around to visit with more students. You cannot engage every student but you can involve more than just the front row.
Keep it interactive. Have group work or use a "flipped class" method and do "pop-up lectures" on concepts that many students seem to be having trouble with. These "pop-up lectures" can be 10-15 minute mini-lectures.
Recognize that what may work one semester may not work in another. Classes have "personalities."
Have the students talk to each other. Have the students discuss answers in small groups before returning to the whole class.
Use theme music! If the holidays are nearing or if you are covering a topic that is mentioned in a song, play it as they come in!
Give bonus points, create competition for fastest (correct) answer to questions.
Give bonus points if they catch you making a mistake!
Use jokes, humor, cartoons, images in PowerPoint.
Have the students give you jokes and tell the jokes in class.
Meet with the students for lunch or for "pizza with a prof"

Conclusion

It has been stated that students need to be provided with the best possible environment for learning, with the instructor as the catalyst for generating that ideal condition. In doing so, students will take with them those unique learning experiences into other classes and hopefully into their professional careers. Finding new ways to connect with students is the key to making a class interactive and enjoyable for student learning and success. Adopting some of the methods mentioned in this work, while also considering other strategies for reaching students in large classrooms, will help to make the large classroom a better learning environment.

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