TEACHING STATEMENT

MCCABE OLSEN

This teaching statement consists of three parts. First, I briefly outline my general philosophy for teaching mathematics. In the second section, I detail my classroom and course structure, including my focus on collaborative learning, use of technology in the classroom, and future teaching plans. Finally, I conclude with future plans outside of the classroom concerning mentoring and student research, as well as outreach.

1. My philosophy: Guiding principles for teaching mathematics

My goal in the classroom is to emphasize three main ideas:

Mathematics is inherently collaborative. Regardless of whether we consider a research level mathematician or a student in a college algebra course, collaboration almost always yields more fruitful results than individual effort.

Mathematics is exploratory. Successful study of mathematics relies heavily on inquiry. The ability to ask coherent questions vastly improves the level of comprehension and thus I view this as a point of emphasis.

Mathematics is beautiful. To many people, math is utilitarian. It is a collection of tools for the sole purpose of solving problems in physics, engineering, computer science, chemistry, et cetera. I do not share this belief. While I recognize that mathematics lends itself well to other disciplines, my love for the subject stems from the intrinsic beauty of its structure. This is something that I try to impart to my students.

2. In the classroom: What I actually do

What follows are some of my concrete strategies that I have used or plan to use for communicating mathematics in the classroom with the end of emphasizing the ideas of my teaching philosophy.

I emphasize group work and cooperative learning whenever possible. This manifests itself in a variety of different ways depending on the classroom setting. For example, when I led Calculus 1 and Calculus 2 recitations, I assigned students to small groups which varied periodically throughout the semester. In each recitation every group would receive one problem and were required to produce a complete solution collectively which would be presented or turned in at the end of recitation. Ideally, these problems would be challenging for individual completion, but approachable and reasonable to complete collectively. In addition to working more effectively through the practice problems, this type of environment relies on students explaining ideas and techniques to one another, which leads to a deeper understanding. As a leader in the MathExcel program, which is an intensive problem-solving workshop that meets more frequently and provides more personalized attention than a typical recitation for Calculus 1 & 2, I instituted these policies in tandem with encouraging each group to work at a chalk board or white board. This practice strengthens collaboration even further by forcing direct interaction between all group members. In almost all cases, this resulted in a greater understanding of the material by all involved.

It is also possible to create collaborative work outside of recitation environments. When I lectured Elementary Calculus as well as Trigonometry, I would often set aside time to devote to such work, and it seemed to have a similar effect as the group work given my Calculus 1 & 2 recitations. The true trial here is finding the proper balance of time for this type of work: too little and it is uneffective; too much and it is impossible to cover the necessary material by end of term. Finding this balance is largely dependent on class size. I have had class sizes as small as 12 and as large as 35. With larger classes, finding this balance is more challenging, but it is a worthwhile pursuit and plan to continue this emphasis on group

Date: September 28, 2017.
work in classes of all sizes. An alternative way to encourage collaborative learning is assigning group projects. When I taught Introduction to Contemporary Mathematics, I had the students, in groups of three, explore Cryptography techniques beyond those that we discussed in class. These projects both encouraged collaboration and exploration.

**Active learning is an integral component to learning mathematics.** Math cannot be absorbed passively by sitting through lectures; to learn mathematics, one must actively engage with the material. I use both highly interactive lecture and inquiry-based learning (IBL), depending on which is most appropriate to a given course. For example in Calculus 1, I like to ask my students why the Intermediate Value Theorem and Mean Value Theorem are true. With a little bit of thought, students can usually give a logical conceptual argument for both theorems and the net result is a deeper understanding of the mathematics at play. Asking deeper conceptual questions like this, when executed with proper wait time, is an incredibly useful tool which often benefits many students in a class. Since mathematics relies heavily on inquiry and the ability to ask coherent questions vastly improves the level of comprehension, I believe that IBL methods should be implemented when possible. The High School Math Circle is modeled in this way and leading a session allowed me to design a project involving Catalan numbers which introduced students to proofs and examples of Catalan structures in an exploratory way. In the future, I plan to expand my use of these methods in courses such as introductory proof writing courses, linear algebra, and more advanced topics.

Unfortunately, not every math course can be taught using IBL methods and often lecture-style teaching is necessary to efficiently cover the material. One strategy to accomplish the same end I have found is to assign homework which contains at least one open ended question to encourage the students to predict what is to come in the material. For example, in Contemporary Mathematics, I included a question with the intention of getting the students to guess the Four Color Theorem. In my recitation sections, I actively encourage my students to not only work together, but ask each other questions to ensure they are correct. I feel that this encourages the students to be more comfortable asking questions about mathematics in general, which is the goal.

**Technology, when implemented properly, can be a powerful classroom tool.** That being said, use of technology in the classroom for its own sake offers little benefit. Subsequently, I try to use technology in my classrooms whenever appropriate. For example, when teaching a first calculus course such as Calculus 1 or Elementary Calculus, graphical tools often improve conceptual understanding of the material. The freely available online software Desmos© can be easily used to demonstrate many concepts such as the Fundamental Theorem of Calculus. In Calculus 3 courses, Maple© and SageMath© are excellent demonstration tools for a variety of concepts, such as helping students visualize quadric surfaces and saddle point. I plan to continue implementing technology in my courses in this way in the future.

I balance my presentation of mathematics between its intrinsic beauty and its useful applications to other disciplines. For example, both in teaching Elementary Calculus and leading Calculus 1 recitations, I try to emphasize that the Fundamental Theorem of Calculus is actually a somewhat shocking and indeed beautiful result. In particular, I have students compute the area directly, evaluate using the antiderivatives, and then I ask them to justify why the answers agree. In most cases, this serves to highlight the beautiful, unexpected connections which appear in mathematics.

Depending on the course and the associated student audience, I have noticed that this approach must be adjusted accordingly. If teaching an upper division undergraduate course on Abstract Algebra, one could focus almost entirely on the beauty, but in lower division courses there is need for balance. For example, when leading our local High School Math Circle, I designed a project which almost exclusively emphasized the beauty of Catalan Numbers. In contrast, when leading Calculus 3 recitations, I must balance my emphasis of the beauty of theorems such as Green’s Theorem with its practical applications in physics and engineering so as to appeal to more of my students who may hold a utilitarian opinion of mathematics, as many of them are engineers.

**I support students dealing with math anxiety.** Mathematics has a strange place in society: it is vital for advancement, but it terrifies people. As any mathematician will tell you, mathematics is one
of very few things people take pride in not understanding. If students approach mathematics with these attitudes of fear and indifference, it is impossible for them to embrace the exploratory nature mathematics; it is impossible for them to see the inherent beauty in mathematics. Subsequently, I feel that it is my duty to change these attitudes in my students whenever I can. One approach to this end is to ban negative language about themselves or their mathematical ability in the classroom. For instance, students are not allowed to say “That was stupid,” or “I’ll never understand this,” or “This is impossible” in the classroom. Instead they can say “That was a productive mistake,” or “This might take me a long time and a lot of work to figure out,” or “There is something interesting and subtle in this problem.” Training students not to use defeatist and fatalistic language towards their mathematical abilities leads to a more supportive environment and eliminates some of the psychological barriers to success in mathematics. In addition to changing language, it is also vital to dispel common misconceptions towards mathematics. For example, many people believe that success in mathematics is based entirely upon innate abilities. This is, of course, far from the truth. Those who find success in mathematics do so through much hard work. I tell my students that I did not realize that I wanted to pursue mathematics until the second year of my undergraduate studies. Before that, I didn’t even think that it was an option because I was not “good at math.” But the truth is, I am good at math because I worked very hard to learn mathematics and found some success. I think that this is a very valuable lesson which helps change attitudes towards the subject.

3. Outside of the classroom: Research Mentoring and Outreach

I am excited about the prospect of mentoring student research in mathematics. Many of the questions in each of my research projects are suitable research questions for students at both the undergraduate and graduate levels. For example, many questions about rational polytopes and Ehrhart Theory are accessible to a student who has only taken linear algebra and seen some basic combinatorics. Some specific questions from my research program in this category are classifying Hilbert bases for lecture hall cones and determining reflexive dimension of lecture hall polytopes. Some of my other research questions, such as the studying toric ideals and Gröbner bases for lecture hall cones, would be accessible to advanced undergraduate with a background in algebra. Additionally, certain other questions, such as the coinvariant algebras for Hibi rings, would only be accessible to a student with exposure to commutative algebra and poset combinatorics. Subsequently, such questions would be ideal for a student at the graduate level. I look forward to the prospect of working with students at any level on mathematics research and would also be interested in pursuing other topics and problems in line with the interests of the student(s).

I have been a part of outreach programs during graduate school and wish to continue these pursuits in the future. In particular, I have been involved for the Graduate Scholars in Mathematics program at the University of Kentucky, which is a program designed to benefit underrepresented groups in mathematics. I would like to contribute to programs designed to increase diversity in mathematics such as this in the future. Another interest is outreach to high school students. I have been involved with the Central Kentucky High School Math Circle as a leader and an assistant. I hope to contribute to and help lead similar programs during my career.