Teaching Statement

Mathematics is a fun, vibrant and vital discipline. It contains some of the greatest triumphs of human thought, serving as the cornerstone for much of the sciences. Proving theorems, thinking critically, solving difficult problems, searching for hidden structure, investigating the unknown and applying theory to real-world problems are some of the many aspects of the subject that thrill me. As a teacher, I enthusiastically share my joy and love of mathematics with my students, seeking to inspire them with a passion for the subject by demonstrating that same passion myself.

I have thoroughly enjoyed teaching Holy Cross students at all levels of ability. I find them to be bright, inquisitive, motivated, respectful and friendly. They work hard and have extremely busy lives outside the classroom. I care about their well-being and truly want them to succeed academically. Whether its through office hours, email, classroom contact, a supportive chat in the hallway or expressing interest in an extra-curricular activity, I continuously send a strong message to my students that I am their ally in their development as young mathematicians.

I have taught twelve different courses since arriving at Holy Cross, ranging from introductory calculus sequences to advanced upper-level courses in modeling, differential equations and dynamical systems. Combining two of my favorite subjects, I designed and taught twice an interdisciplinary topics course in mathematics and music. Having studied music history and theory extensively as an undergraduate at Oberlin's world-renowned conservatory, it has been a treat to create a course that draws on some of this intellectual background. In preparing my lectures, I have greatly expanded my knowledge and appreciation of music and have benefited considerably from the guidance and experience of the music department's faculty and staff members. In the future, I hope to incorporate this class into the "Natural World" cluster of the Montserrat (First Year Experience) program.

One of my primary teaching goals is to create a fun yet instructive atmosphere for learning. In my introductory courses, I find it is critical to engage students frequently throughout the class. Students at this level rarely have the attention span to focus on difficult concepts for more than ten minutes. To keep students engaged, I work many sample problems at the board, asking frequent questions and soliciting student input. This is particularly fruitful as a method of identifying which concepts are causing students the most difficulty. I am flexible when organizing a particular class, willing to shift gears, slow down and work additional problems if necessary. I have always been an advocate of the "less is more" philosophy in introductory courses.

To keep students actively engaged in the classroom, I often break them into groups to work on practice problems. This can be done formally using a prepared worksheet or on the fly amidst a lecture. As students work together solving problems, I walk around the room offering suggestions and observing their progress and struggles. One of the benefits to in-class cooperative learning is the growth of student partnerships, providing an extra resource for assistance on homework or for exam preparation. I always encourage students, at any level, to form study groups outside class as a valuable asset to their learning. This suggestion is clearly stated in the "How to succeed in this course" section of every syllabus I distribute.

Another technique I find useful (and fun) for engaging students is a game called "Switch" that I learned from Professor Edward Burger at Williams College. I have had great success with this game in my introductory calculus courses, particularly in drawing out the more reserved students. The game starts with students pairing up, each beginning with a blank piece of paper. A problem is announced, such as,

$$\text{“Find the derivative of } f(x) = \frac{3x-1}{2x+5}\,\text{,”}$$

whereupon each student commences solving the problem on their own paper. After a brief amount of time, perhaps thirty seconds, I say, "Switch" and the students swap papers with their partners, continuing to work the problem from where their partner left off. If their partner has made a mistake, the student is expected to find and correct it before proceeding with the problem. This continues until I declare another switch, repeating the checking and solving process. If a student finishes early, they are instructed to check their work and/or assist their partner.

This activity does far more than just engage students. First, students learn to evaluate another person's work. They cannot proceed until they believe their partner is correct, so this requires an understanding of their partner's thought process. Second, for problems with more than one approach or a less obvious initial step, the game encourages the ability to think in multiple directions, for their partner may have chosen a completely different method than their own. This encourages students to have an open mind. Third, students often end up helping and teaching each other. This not only solidifies their understanding but also develops their ability to work collaboratively.

The structure of the game seems to provide much incentive for students to find the correct answer. They often push themselves to finish up the problem before I can call for another switch. The first time I used this in *Calculus for the Social Sciences I*, students had so much enthusiasm during the game that I had to quickly teach the chain rule in order to find some fresh problems to assign. In that single fifty-minute class period, we solidified (at least as an algorithm) the product, quotient and chain rules! Their wonderful attention that class was refreshing.

Another hallmark of my teaching style is to be highly available outside the classroom. Meeting with students individually or in small groups is one of my favorite teaching activities. Although I usually offer four to five specific weekly office hours, I also encourage students to set up alternative appointments or just drop in when my door is open. Office hours are a wonderful opportunity to gain insight into a student's thought process, to encourage and advise struggling students, to praise those who are excelling and to get further acquainted. When helping students, I strive to offer guidance by suggesting an approach to a problem rather than simply giving the correct answer. Expecting students to make the connections themselves and carry out the computations on their own leads to a deeper, more lasting understanding. In addition to office hours, I also encourage inquiries over email and frequently send the entire class my response to a pertinent student question.

Throughout my teaching, I endeavor to make challenging mathematical concepts look easy. Having a strong grasp of the subject allows me to reach for a natural, simplified presentation of difficult material. I regularly provide written and verbal "punchlines" during my lectures so that students see the main point. To drive it home, I might repeat a punchline multiple times or box it creatively on the board. I am a strong proponent for teaching proofs and advanced concepts to our lowest-level students. This does not necessarily mean applying the same standard of rigor as I would in an advanced course. However, I think it is critical that a mathematics student understand the rationale and justification for a theorem, rather than just applying or memorizing it thoughtlessly.

For example, in my introductory math and music topics class, *Math 110*, I include a unit on rational and irrational numbers as part of a broader investigation of various musical tuning systems. Historically, the move away from Pythagorean and Just Intonation tuning systems toward the modern Equal Temperament is mathematically best captured through an understanding of rational and irrational numbers. To appreciate the delicacies of the subject, I teach students two famous arguments proving that the $\sqrt{2}$ is irrational (its decimal expansion never repeats nor terminates). Although typically reserved for math majors who have already completed several courses in the major, I carefully introduce the material to my *Math 110* students and ask them to extend the result to other roots on their homework. Ultimately, students show that the twelfth root of two is irrational, leading to the rather ironic conclusion that our current "rational" system of Equal Temperament is based on an *irrational* number. Thus, a tough concept is made a little simpler and more relevant, by placing it in an interdisciplinary context.

Another crucial feature I employ to improve student comprehension of difficult material is the use of technology in the classroom. In my *Multivariable Calculus* lectures, for example, I frequently use the mathematical software package Maple as well as the Macintosh 3d graphing calculator on my laptop computer to help students visualize functions of several variables. Many students described how helpful this was on their course evaluation. In the calculus courses *Math 132* and *Math 136*, I use graphics software written by former student Rob Truxler (HC '06) to illustrate the method for finding the volume of a solid of revolution. In *Dynamical Systems*, I use various Java applets available from the Boston University Dynamical Systems and Technology Project to bring the course material alive. In this course, computer technology allows students to investigate complicated bifurcation diagrams and explore intricate fractals. In the upper-level differential equations sequence, I use computer software to visualize phase planes, bifurcation diagrams, Fourier series and solutions to the wave equation. In-class demonstrations on the computer improve student understanding, provide visual aids to challenging material and spice up my lectures.

Nearly all of my courses contain lab days designed for students to work on assigned computer projects in groups of two or three. These projects are intended to reinforce course material, providing an important supplement to my lectures. Certain projects I have created dovetail nicely with my research, serving to demonstrate possible applications of the subject matter. Some examples include applying Newton's method to a "bad" polynomial in calculus courses, finding the libration points of the restricted 3-body problem in *Multivariable Calculus* and solving the two-body problem in *Ordinary Differential Equations*. Writing is an important aspect of the projects and students are graded on their ability to submit coherent, well-written reports. While some students dislike these computer labs, usually out of frustration with the software or from a repulsion to the concept of writing in a math class, the end result is often a deeper understanding of the subject material and an enhanced ability to work cooperatively.

Another advantage to assigning computer labs, particularly those with a connection to my research, lies in generating student interest to pursue further academic study. I am a strong supporter of undergraduate research and frequently encourage talented students to apply to summer research programs designed for undergraduates. To date, I have worked with six students on research projects (five at Holy Cross) and co-authored two publications with student authors. Specific details on my research with undergraduates is available in my Scholarship binder in the section *Research with Undergraduates*. Student researchers are inquisitive, enthusiastic and bring fresh ideas to hard problems. Mentoring and collaborating with undergraduate researchers has been an immensely rewarding activity for me and I am most grateful to be a faculty member at an institution that encourages and supports this vital integration of teaching and research.