Teaching Statement

Mathematics is a dynamic paradigm, full of questions and conjectures, as well as fanciful imaginings. The act of learning mathematics is not a rigid, non-expressive endeavor, but rather a personal exploration, guided by logic and diligence, as well as creativity and personal insight. Mathematics has the ability to awaken curiosity and wonder in students, while at the same time encouraging them to think critically and creatively to solve problems, challenge their assumptions, and communicate their thoughts and ideas precisely and effectively, skills that are highly prized in a college graduate of any major or career trajectory.

As an educator, I aim to cultivate the desire ask and answer questions and the ability to engage in balanced intellectual discussion and argument. I want my students to be deep thinkers and effective problem solvers and to have the confidence to tackle the great problems of their time. To this end, I strive to do the following when I teach mathematics:

- Encourage the making of mistakes as the only path to true learning;
- Enable students to be active participants in their learning process;
- Emphasize the importance of deep understanding, as opposed to superficial familiarity;
- Allow collaboration and promote the communication of ideas.

Many of these tenets are inspired by my experience with Inquiry Based Learning classrooms, and I discuss how I have been influenced by this style of teaching below. I also discuss teaching liberal arts majors and pre-service teachers, and describe mentoring and advising undergraduate research.

Mistake-making and Developing active learners

A basic tenet of my teaching philosophy is that students must be actively engaged in their own learning process. For this reason, my classroom is structured around student activity, often in the form of group work, in-class exercises and activities, and student presentations. These techniques help students to make connections between what I've been saying and the reality of solving problems on their own. I find that it is possible to transform a classroom from a dull, ineffective lecture to a bustling hub of intellectual activity simply by giving the students a way to actively participate in the learning process.

One of the most important steps that I take to increase student engagement is to champion the idea that making mistakes is an essential part of the learning process. Something that mathematicians take for granted is that, when presented with a problem, we immediately sit down and start trying to solve it. This impulse seems innocuous enough, but in reality, it is an important quality. Most students are terrified of making mistakes, often to the point that they will not even begin to work on a problem because they are afraid their first step will be wrong. This state of paralysis is a major hurdle in their learning process. For this reason, I make a point to stress over and over again the importance of simply trying something, making a mistake, understanding the mistake, and trying again. When students start to realize that it is okay to make mistakes, it removes an enormous pressure and allows them to actually begin to learn.

Finally, it is important to remember that many students, especially in lower level courses, struggle with learning mathematics. I make a point to remind my students that struggling is a necessary part of the learning process. I know how important it is to give students a boost of confidence when they feel as though they are failing and to be patient with them. I often receive student feedback praising my patience and tolerance, which is something I am very proud of.

Creating effective communicators and collaborators

An important part of student activity in class revolves around working in groups, presenting work at the board, and generally communicating mathematical thought. Sometimes students are initially resistant to this methodology; but it is of great importance, because it teaches collaboration and communication. Also, when students work in groups, some group members become teachers to the other group members, which is beneficial to all involved. There is no better way to solidify understanding of a concept than by teaching it to someone else. Another advantage to having students work in groups is that there is less pressure on individuals when work is presented at the board – the work being presented belongs to the group, and is not a direct reflection of any one member.

This methodology benefits mathematics students and non-mathematics students alike by producing an organic, energized classroom in which cooperation and discussion are paramount. When students present solutions at the board, the rest of the class is encouraged to ask questions, propose counter-examples, and offer simplifications. This set-up models the collaboration and vetting process present not only in modern mathematical research, but in any professional setting.

It is important to me that my classroom is a place where students feel comfortable asking questions, and I go to great lengths to establish a pressure-free learning environment. I have a natural, easy-going manner that I find puts students at ease, and I always encourage questions and inquiry of all sorts.

It is worth noting that, while many of these ideas and techniques are easier to implement in small enrollment courses, they can also be adapted to improve student learning in larger courses. For example, even in large lecture courses, I make sure to emphasize student participation, group work, and communication of mathematical ideas.

Inquiry Based Learning

One of the biggest influences to my teaching philosophy has been the time I have spent working in Inquiry Based Learning classrooms at The University of Texas at Austin. I applied this methodology with great success in my teaching at Indiana University. Inquiry Based Learning (IBL) is a student-centered approach to teaching mathematics that emphasizes the discovery process. Generally, students are given notes containing only the relevant definitions and the statements of the lemmas, propositions, theorems, and corollaries that will be encountered, and the students must provide the missing proofs. Apart from developing a deep understanding (even mastery) of the subject at hand, this learning method cultivates a number of important skills.

My experience with IBL has taught me a lot about the importance of developing problem solving skills in students. It is much more valuable to give students the tools with which they can approach and solve problems, than to simply show them the solution. For this reason, I always emphasize problem solving techniques, such as drawing a picture, considering one or more examples, or making a simplifying assumption. As George Pólya said, "If there is a problem you can't solve, then there is an easier problem that you can solve; find it."

I've also learned the importance of allowing students to approach problems in their own way and to learn from their own mistakes. Students are often frustrated when they realize that I am not willing to just give them the answer. However, the net result of this approach over a semester is positive, as they often admit themselves. A student who has failed to solve a problem in multiple ways before arriving at the solution is much more likely to truly understand the concept and to remember it going forward. In fact, it is not uncommon for an student to come up with a novel approach or interesting new proof of a known theorem.

A great strength of IBL is that it stresses personal exploration, which leads to deep understanding. Many people these days mistake familiarity for understanding. This issue can be particularly serious in a mathematics classroom. If a professor is an exceptionally talented lecturer, then students will often leave the class in awe, possessing a great sense of understanding, only to be unable to complete the homework assignment later. For this reason, I stress the notion that true understanding is best arrived at by being actively involved in learning; we learn by doing.

When it comes to testing comprehension, an excellent way to see if someone really understands something is to ask them to explain it to you. I utilize this fact in the classroom, where I make the asking and answering of questions between peers an integral part of the learning experience.

Teaching pre-service teachers

Not only is the IBL methodology and emphasis on collaboration, communication, and problem solving mentioned above highly effective for teaching rigorous mathematics to math majors, these techniques also make for excellent educational tools when addressing liberal arts majors and especially pre-service teachers. The main reason for this is that the techniques stress the learning process, which is valuable to any student, even if they are not particularly interested in the subject material at hand, as is often the case. Any student, regardless of their goals, can benefit from learning how to solve problems creatively, make mistakes yet persist in trying, and understand and communicate their work effectively.

As an instructor at Austin Community College, I taught a class called College Math, which targets liberal arts majors. I found that the students responded well to this methodology and were relieved to be participating in an interesting, non-traditional math class. As a postdoctoral instructor at Indiana University, I taught upper-division math classes to pre-service K-12 teachers. I feel that this demographic is especially well-served by these techniques, since there is explicit focus on meta-cognitive aspects such as asking themselves where they are stuck, discussing alternate approaches, and determining whether or not they truly understand the solution. These students also understand that best practices in teaching center around student engagement and active learning techniques, and they benefit from seeing these techniques modeled in their own education.

I get a particular enjoyment out of teaching pre-service teachers; it is a way of stretching my influence beyond my own classroom, to the many, many students my students will someday teach. I feel that it is of utmost importance, especially in a society in which many students have come to display a type of phobia of mathematics, that we concentrate on preparing talented teachers who can go out and spread our love of mathematics and create enthusiastic learners of all ages.

Undergraduate mentoring and research

Learning mathematics is not a lonely, individual pursuit. In my life, I have been extremely lucky to come in contact with many great teachers, advisors, colleagues, and students, some of whom have deeply influenced my career as a mathematician and educator. For this reason, I believe the opportunity for undergraduate-graduate learning partnerships and faculty-led undergraduate research is an important aspect of undergraduate and graduate education.

As a graduate student at The University of Texas at Austin, I had several opportunities to mentor undergraduates. I participated in the university-wide Intellectual Entrepreneurship Pre-Graduate Internship program, which targets underrepresented minorities and first-generation college students in an effort to raise graduate school awareness and preparation. I also participated in the math department's Directed Reading Program, which pairs enthusiastic undergraduates with graduate student mentors in semester-long learning partnerships, culminating with a night of presentations by the undergraduates. Many of the undergraduates with whom I worked while at UT

Austin went on to graduate school in mathematics or physics, citing these learning opportunities as being highly influential and motivating for them.

In the fall of 2015, fellow postdoc Corrin Clarkson and I started the first-ever Directed Reading Program in the IU Mathematics Department, and in the fall of 2017, as a new postdoc at University of Georgia, I started another such program. The positive feedback that I have received from undergraduates, graduate students, and faculty has been overwhelming, and I am very proud to have helped place these departments among the dozen or so universities across the country with Directed Reading Programs.

In the summer of 2016, I participated in the Indiana University Minority Serving Institutions STEM Initiative, which is a partnership between IU and a collection of Historically Black Colleges and Universities that aims to increase the number of African-American graduate students, scholars, and professionals in the STEM disciplines. I mentored a young woman, who aspires to be a math professor, in a reading of point-set topology. This opportunity was invaluable for her professional growth.

My research interests, which include knots, surfaces, and manifolds, lend themselves well to undergraduate research and exploration. Students are immediately attracted to the beautiful imagery and constructions in these fields and are often eager to learn more. On the other hand, these fields are profound and full of mathematical complexity. It is often easy to state problems that students can understand but that have yet to be solved. For these reasons, I believe these fields make for an ideal entry point for many undergraduates to get involved in mathematical research. This is evidenced by the following two REU projects that I supervised while at IU.

In 2015, I worked with an IU student named Sam Pilgrim. We completed a project focused on investigating the connection between the braid group and new objects called bridge trisections, which were introduced by Alex Zupan and I as a new way to describe knotted surfaces in four-space. Sam's work led to a novel and elementary proof that small-complexity bridge trisections are trivial, and Sam has continued to pursue related questions involving representation theory and algorithmic computation of knot invariants. Sam is now a graduate student at the University of Hawaii. Sam confided to me that it was during our REU project that he came to understand the beauty and difficulty of research mathematics and that he decided he wanted to go to graduate school in mathematics.

In 2016, I worked with James Dix, a student form UT Austin. James and I studied knotted Klein bottles in four-space. The project resulted in a new construction of such surfaces that is capable of producing examples with very interesting behavior. We are currently expanding and preparing our findings for publication. James is now a graduate student at UC Berkeley.

Projects such as those described above embody my belief that learning and research should transcend traditional boundaries between undergraduate students, graduate students, and faculty – a philosophy I will continue to embrace as an undergraduate and graduate educator.