At the University of Minnesota and UCLA, I have taught Precalculus, Calculus, advanced undergraduate courses, and programming. I have also taught in various enrichment and outreach programs at the University of Minnesota, UCLA, and the University of Chicago. My teaching methods emphasize student involvement and engagement, and I’m particularly interesting in getting women and other underrepresented groups more active and interested in math. I have recently become involved in developing online, interactive textbooks.

Background

My interest in teaching began when I was an undergraduate at the University of Chicago. There, I was introduced to Inquiry-Based Learning (IBL), while working as a teaching assistant for Calculus and in the Young Scholars Program (an enrichment program for middle and high school students). IBL is a student-centered approach to teaching that focuses on the process of discovering mathematics. In an IBL class, students are presented with problems and questions that guide their learning, and they learn mathematics by investigating these questions. IBL has proven to be particularly effective at teaching thinking and problem solving, as well as increasing students’ interest and excitement in mathematics. [1]

As a graduate student at UCLA, I served primarily as a teaching assistant for a variety of courses. Most graduate students at UCLA are much more focused on their research and spend a minimal amount of time on teaching. However, as I progressed through the program, I found myself becoming more and more interested in my teaching. As I gained experience as a TA, I started to think about ways that I could be more effective as a teacher. I drew on my experience using IBL at UChicago, and started thinking about how to make the students more active in class.

At UCLA, it was typical for a TA to spend the entire TA session going through solutions to whatever homework problems students asked about. Although I started out teaching this way, I found that many students were just copying down solutions without really learning anything from the discussion section. I decided to change the format of my class, and I began to incorporate active learning methods. My discussion section became focused on group work and student led discussions, and I found that the was much more effective at engaging the entire class.

In Fall 2015, I had my first opportunity to be the lecturer for a course, the first quarter of single variable calculus. At the beginning of the course, I taught the way that I had been taught: by lecturing with very little participation from the students apart from the occasional question. A couple of weeks into the course, I started to rethink this approach. I decided to return to my old format from discussion sections: I would spend a few minutes introducing a concept, work through an example or two, and then spend most of class time having the students work on problems in small groups. In addition to the students being more actively engaged with the material, I found that I was able to catch some major mistakes immediately, so these were corrected before they even started on their homework. By the end of the course, I was only spending about 5 minutes of class time lecturing, and the remaining 45 minutes was spent on group work.

As a MathCEP postdoc at the University of Minnesota, my work is focused primarily on teaching: I teach calculus in UMTYMP (a program for advanced middle and high school students), teach a regular math department course, supervise an undergraduate research project, and am involved in various outreach and enrichment activities. In this postdoc, I have had the opportunity to collaborate and learn from my colleagues, who also have a strong interest in teaching. I have found these interactions to be invaluable, and they’ve had a huge impact on my development as a teacher. My experiences as a Project NExT fellow have also had a tremendous influence on my teaching,
inspiring me experiment and challenge myself as an educator.

**Intuitive Approach**

When determining how to introduce new material, I begin by considering the question: what is the natural development of this content through a series of questions? For instance, when introducing Huffman Codes to my Coding Theory class, we talked about the goals of making codes both efficient and accurate. We started with using the ASCII binary values to encode an English message. After having students encode and decode these types of messages, I asked the students to come up with ideas of how to use fewer binary bits for the code. They suggested dropping unnecessary digits and restricting to lowercase letters, which got us to five bits. I then asked, “if in an English message, there are a lot of e’s and not very many q’s, what if we could use fewer bits for more frequent letters?” From there, we talked about how this could make the code ambiguous, and we came up with the idea for prefix codes. In order to keep track of what prefixes were used, we figured out how to use a binary tree to represent our code. From there, we talked about balancing the frequencies of different letters and eventually came up with the algorithm for Huffman codes. Throughout this introduction to Huffman codes, we took pauses for students to try out codes, work together, and discuss the questions we were considering. By approaching the material this way, I’m able to encourage students to think and actively engage with material that would normally be introduced through traditional lecture. I try to spend as much class time as possible with students working on problems, while also making sure we cover the material they need.

I continue to follow this structure any time I talk about problems with a student. Instead of showing them how to proceed or giving them the next step, I ask them leading questions to help them come up with the answer on their own. Talking through a problem in this way trains students to analyze problems, think about what tools they have available, and figure out how to apply those tools. This way, they get in the habit of thinking through this problem solving process, and are better equipped to solve future problems, even if they’re unrelated. As one of my students wrote in evaluations, “she guides me to the answer instead of just showing me the answer, which greatly aids in my learning progress.”

**Teaching Methods**

Building on my experience with IBL, I’m always looking for new and innovative ways to get students engaged in learning. As a MathCEP postdoc and Project NExT Fellow, I have had great opportunities to learn about different active learning methods and incorporate these into my teaching.

When teaching calculus in UMTYMP, each week we have an hour long lecture with a large group of students followed by an hour where students break up into sections to do group work. With such a small amount of class time per week, we give our lectures using iPads, so we can prepare slides in advance to save time, but we can also write on the slides as we go, making the lectures more dynamic and interesting to students. The versatility of using an iPad for lectures has been a big change in my teaching style. I’m able to incorporate more complicated illustrations and visuals that help the students understand the material, while still maintaining the versatility of being able to write on the slides and make changes during the lecture. While using the iPad, I have continued to break up my lectures, reserving a significant amount of lecture time for students to try out problems themselves, and going over solutions after.
In my Error Correcting Codes class last year, I experimented with a flipped classroom. I had students watch videos or do readings prior to class, and then spent the class time on groupwork. In order to make sure students came to class prepared, they had to answer a few questions on the material before class. To incentivize students to actively participate in the groupwork, I graded them on attendance and participation. I initially received some push back from students about this format, and I surveyed them in order to find out how I could make this format more effective. I incorporated a short review of material at the beginning of class, and time spent going over solutions at the end. After these changes, students were very happy with this format, and they found the flipped class very effective for their learning. In evaluations, most students commented that they liked the structure. For example,

“I loved this class structure. This learning style really worked for me and I feel that I got more from this class than any other class I have taken before.”

This experience teaching a flipped class was very rewarding, and I plan on incorporating elements of this into future courses.

I have also incorporated projects into my advanced undergraduate courses. I ask students to pick a topic that interests them, and I provide them with a list of suggestions in case they don’t have something in mind. These topics have varied widely according to the interests of the students. Students interested in programming have implemented some of the algorithms or protocols that we covered in class; students interested in modern applications have learned about cryptocurrencies or secure voting systems; students interested in pure math have learned about the Riemann Hypothesis or quadratic reciprocity; students interested in history have learned about the historical context and development of codes and ciphers. This allows students to connect what they’ve learned in class with the world outside of class, and gain experience learning about a topic by reading papers and finding their own sources rather than consulting a textbook. Once they researched their topic, students wrote a paper on what they learned and prepared a presentation for the class. The format of the presentation can be an in-class presentation, a video, an interactive webpage, an academic poster, a podcast, an app, or another format of their choice (subject to my approval). The quality of these presentations has been remarkable; in particular, one student wrote and animated a science fiction story based on the use of concatenated codes in deep space communication. For the final component of the project, I have the students write about what they learned from each others’ presentations.

Underrepresented Groups

In addition to raising the level of the class as a whole, incorporating active learning methods have proven to have a positive impact on the achievement of underrepresented groups in mathematics, both in my experience and in the literature. [2] I have found that students from underrepresented groups feel very isolated in a traditional lecture setting, sometimes feeling like they don’t belong and everyone understands the material except for them. Once they start working on problems with other students, building relationships, and understanding the material together, these feelings of other-ness tend to fade away. The student realizes that they aren’t alone in trying to understand the concepts, and they start to build a network of classmates that they can discuss problems with. They are able to focus on the material rather than the worry that they’re different or not as good as the other students.
Interactive Textbooks

Expensive textbooks can be a hidden cost of college education for students. Particularly for economically disadvantaged, first-generation, and non-traditional students, spending hundreds of dollars on textbooks each semester can be prohibitively expensive. Some students choose not to buy the textbooks as a result, and their grades suffer as a result. Online, interactive textbooks can provide a no-cost alternative. They’re also more versatile than traditional textbooks, and can be more effective for students with different learning styles.

I’ve been working on writing an interactive online textbook to replace the UMTYMP Multivariable Calculus book, using the Ximera platform developed by Ohio State. This platform offers a huge amount of versatility in how material is presented. I can incorporate videos, audio, interactive modules, and interactive problems. The variety in how material is presented provides a huge advantage for students who don’t learn well by reading from a textbook. They can use the online textbook in a way that works with their personal learning methods. By incorporating problems into the text, students can get instant feedback about their answers, and check their understanding.

Ximera can also be used as an online homework system. In addition to writing materials for the UMTYMP Multivariable book, I’ve contributed to some of the programming for checking answers. Ximera verifies students’ answers by checking that they are algebraically equivalent to the answer given by the instructor. My contributions to this have included implementing matrix operations and implementing multivariable polynomial operations using Gröbner bases. For instance, it can verify that $x^2y + z^2y$ is equal to $x^2 + z^2$.

I plan to continue developing materials for interactive online textbooks for future courses.

Conclusion

By having students actively engage with the course material and explore their own interests related to the course, I have been able to increase my students’ performance and interest in my classes, in addition to helping them develop important problem solving abilities. By incorporating active learning methods into my classroom, I have also been able to improve the experiences of students from underrepresented groups in mathematics. I will continue to evaluate and adjust my teaching in order to be a more effective teacher, incorporating innovative teaching methods where they are effective.

References
