

## Philosophy Motivates Undergraduates in Mathematics

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Teaching seminars on the philosophy of mathematics is good for students and good for educators. I will explain a model I have used for a discussion seminar around the philosophy of mathematics including its impact on the students directly involved as well as in my broader duties as a mathematics teacher. These projects have been very helpful in pursuing my research interests as well as having an avenue to explore connections between faith and mathematics. I will conclude with a few of the risks and rewards that you should be aware of should you consider taking on similar activities.

Over the last five years, I have organized discussion seminars and research projects for students. I did this to reach a specific group of students and to provide impetus for my own growth. The students I work with are those seeking opportunities beyond the limited class offerings our college has in mathematics. Typically students solve this by pressing through the sophomore level courses and only then branch out after transfer to university. But I thought I could do more by including students in my personal interest in the philosophy of mathematics. Through reading good books, asking insightful questions, and pushing higher order thinking through writing, students' lives are being changed and I am growing intellectually.

The next three paragraphs outline the way I have organized my seminars. For those more interested in the outcomes than the how-to, come back to these paragraphs if and when you decide to explore a project like this for yourself.

I did my undergraduate studies in a discussion seminar format and have continued using this familiar structure.<sup>1</sup> I meet with 4-10 students for a book discussion every Friday after other classes have ended. Everyone is expected to contribute with participation being measured by students coming prepared with typed questions based upon the readings. Since questions are written in advance, even quiet students are able to contribute to the discussion. In terms of work load, I expect students to read 1-2 books per quarter credit. I have found this ample material for discussion while laying the groundwork for students to write a related essay. We always set aside a week for students to share their writing and provide peer feedback.

In putting together these seminars, I have taken advantage of two flexible programs at my college:

studies courses in our catalog. However, these are rarely used. I have found a topics class a great avenue to reach students and simple to arrange logistically. In addition to using the special topics heading, I have used the same class structure in working with students on projects for an honors option. Our honors program allows students to do a research project connected to one of their classes. The level is intended to be similar to what a student might face in upper division courses (recall, I teach at a two year college).

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<sup>1</sup> Following two years of community college, I completed my undergraduate studies at The Evergreen State College in Olympia, WA.

More importantly, students are given opportunity to discover knowledge for themselves. As one student asked, “Do you think creativity is a requirement for doing math?”<sup>2</sup> These projects give students a chance to answer that for themselves by exploring mathematics outside the boundaries of their standard textbooks.

From my vantage point, there is little difference between the two programs (honors and special studies). Most seminars include honors and credit students. However, it can make a difference to the students. Limiting it to a credit class would (necessarily) add to the tuition expenses. On the other hand, working strictly under the honors heading would exclude all but the best students from eligibility. The most important aspect is to find a framework that works for you and provides tangible motivations to students.

About 45% of mathematics majors attend community college. However, most do not make the conscious decision to pursue mathematics until after they transfer. This impacts the type of students attracted to these seminars. The students I attract are those interested in a challenge, those with an interest in philosophy, and those few decided mathematics majors who are looking for a space of their own apart from the droves of engineering majors in their calculus classes.

Because the class is completely optional, all participants tend to be fully invested. The benefit to mathematics majors is that the seminars give them a leg up after transfer because they have a deeper understanding of the historical and philosophical context in which the mathematics came to be. That is, they better understand the value and application that is behind their studies. More interesting are those that come in without a stated desire to major in mathematics. These students typically are talented in mathematics, but have never considered it their primary focus. It’s not uncommon for the seminar to change their focus as a result of these projects.

Harry Kim is an example of such a student. Harry was a new calculus student to our College. As an international student from Korea, he was the only new face to join my philosophy seminar. All the others were former students of mine. While he quickly established himself in the calculus, the seminar was a greater challenge. Readings I expected to take students two hours, took Harry more than six. With a shy laugh, Harry said, “I learned more English than philosophy in that class.”

But Harry did learn about mathematics and mathematics history. Specifically, he expanded his picture of mathematics as being more challenging than merely textbook calculus. This led him to spend months fixated on the error function; he believed that he could find a clever trick that would could make the unintegratable integrateable. This in turn led him to play with Taylor Series months before his peers ... but these were not the elegant answer he sought. As if one unsolvable problem was not enough, Harry joined the throngs who have sought to unravel the mystery of the distribution of prime numbers. Most

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<sup>2</sup> Alison Mehlhaff, education major. Unless otherwise indicated, student quotations are from note cards collected on the first day of each term. On the card, I ask students for their name, birthplace, native language, an interesting fact about themselves, and one question for me (any topic so long as it is at most PG rated).

recently, he took it upon himself to generalize a solution and in so doing stumbled upon the Fourier series. But to his chagrin, he discovered that someone else had done this first.

When Harry came to me, he was intending to major in chemistry. However, the complexity and mystery of mathematics enticed him. Our reading (The Loss of Certainty by Morris Kline) gave him a glimpse at the beauty of mathematics that textbooks hide behind an inscrutable veil. This project (and others we have worked on) provided Harry a direction and purpose for his studies.

Because of these, my college is experiencing a rise in students (like Harry) who are declaring a mathematics major while still at community college. While not my original goal, I do see it as a success for the philosophy of mathematics in that students are drawn to the field of mathematics when they understand its power and mystery.

In addition to helping those students directly involved, the advent of seminars on the philosophy of mathematics correlates well with my broader growth as a teacher. This might seem counterintuitive because the seminars cause a tug-a-war over my time and attention. On the one hand, the seminars take focus and energy that could be allocated to an algebra or calculus class. They also cause me to focus more attention on the strong and interested students, perhaps leaving less for those most in need of care.

On the other hand, the seminars provide a rich foundation that can be woven into my other classes. A student wrote, "He [Dusty] showed the great background story for math. The story makes me understand and interested in the topic."<sup>3</sup> Rather than each class being a collection of tricks and techniques, the philosophy (and corresponding history) allows me to teach much more holistically. As another wrote, "I like how once in a while he [Dusty] would educate us on the philosophical aspects of math."<sup>4</sup> The availability of these projects also shows that I am willing to go above and beyond expectations (even if students don't avail themselves). Students have begun to look forward to and ask about future offerings. All together, I believe that I am a better overall teacher for having spent this time focused on a few select students.

A surprise to me is that algebra students are just as likely as those in the calculus to ask questions. One student asked, "What is math?"<sup>5</sup> and another, "Did you find out what the purpose of math is in philosophy?"<sup>6</sup> I believe this may be because the lower level students are more resistant to typical math presentations and thus more intrigued that there might be alternative motivations.

To support the hypothesis that this has helped me broadly, I did a more comprehensive analysis of my student evaluations over my tenure at Highline up through 2012. I wanted to know if there was evidence that these seminars were impacting the quality of my teaching. Students were asked: "The

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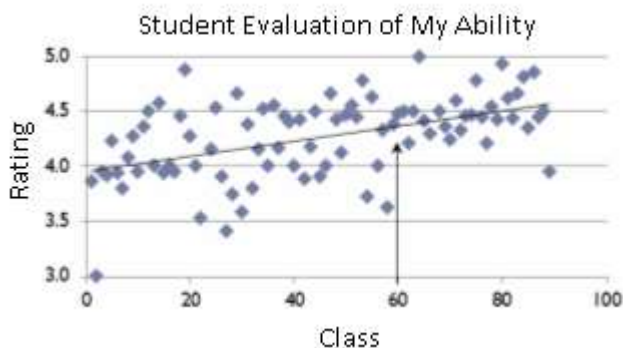
<sup>3</sup> Anonymous comment from a student evaluation, multivariable calculus. This comment was edited for its grammar.

<sup>4</sup> Anonymous comment from a student evaluation, multivariable calculus.

<sup>5</sup> Parker Wilson, a business major.

<sup>6</sup> Claudia Gaudia, an undecided student in a business algebra course.

ability of the instructor to communicate the subject matter has been ..." on a 5 point scale with 1 being very poor and 5 being excellent. The results are given in the graph below with the arrow indicating where I taught my first seminar. The upward trend is obvious as well as a much tighter clustering in the latter third of my career that coincides with when I taught my first seminar.<sup>7</sup>



To be clear, I am not claiming that correlation implies causation or that these seminars represent the only variable impacting my ability as a teacher. For example, the birth of our third child may well have been a major factor in the early variation. Perhaps as likely, I was very raw and it took me a number of years to mature into an effective teacher. But whatever the reason, I believe this shows conclusively that the addition of these seminars not only has not had an adverse effect on my other teaching duties, but may have actually had a positive impact.

As I have shown, these seminars have had a positive impact upon the students directly involved as well as helped me grow into a better overall teacher. But their value to me extends beyond the classroom. There are few (if any) faculty at my college who share my interest in the philosophy of mathematics. Furthermore my community college provides little incentive for professional growth in this field. But these seminars allow me to explore my own interests alongside others. Working with students allows me to develop my understanding in a cooperative setting.<sup>8</sup>

Because the seminars center on reading and dialogue, I have opportunity to practice articulating ideas. Perhaps as valuable, I get to hear the unfiltered questions of students which help me know the issues I must address. As an example, I have had numerous students ask about Godel's incompleteness proofs. The reoccurrence of the question pushes me to learn. I want to articulate clear and insightful answers.

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<sup>7</sup> This graph requires a brief explanation. I taught about 90 classes (through 2012). Each data point represents the average rating given by a single class. As I teach three classes most terms, the data can be read (roughly) three points at a time. Prior to the first project, the mean ranking was 4.2 while afterward it rose to 4.5. I used a chi squared test and verified at the  $\alpha = 0.05$  level that this change was not due to random variation. I should also note that there is a small amount of data missing from this sample from a handful of classes for which I did not collect evaluations. These were almost exclusively before my first seminar and their inclusion (I dare say) would have only strengthened my case that I am a better teacher today than a decade ago.

<sup>8</sup> Never having worked at a research university, I speculate that this may be a key factor in why researchers like to work with graduate students.

Seminars cannot provide a complete solution to this as the concepts are too new to students for them to ask nuanced questions. But it is a stepping stone.

In addition to purely philosophical questions, students also push me toward integration. One student asked, “How has your understanding of mathematics changed your view or understanding of your religious beliefs?”<sup>9</sup> This kind of question is powerful as it pushes me to explore the impact of my faith on my discipline (and vice versa). Where is there time for such analysis and synthetic thinking? At any university, time is at a premium and this question has little credence at the public community college where I am tenured. But students want to know, “How can you connect God and math?”<sup>10</sup> I have found that these seminars give the reason, motivation, and space for me to think in an integrated manner.

Most of the books and articles we discuss do not have an overtly religious tone. If anything, the authors are skeptics who deify mathematics. But the philosophical themes, coupled with my known beliefs and the authors’ clear presuppositions, put some of life’s enduring questions on the table for conversation. A student asked, “Did higher education change your view on religion in any way?”<sup>11</sup> There are some students who want to know, and these discussions provide a platform for them to air their questions.

While nearly all the student feedback I have had regarding philosophy as well as the integration of math and faith has been positive, the work load itself is taxing. Since these projects are not part of my official teaching load, I like to think of it as tithing a credit. Thus I have been selective of the topics and timing. As I get good resources that I want to discuss, I begin to seek out students with whom to partner. By the end of the term, I tell myself “never again.” But like the woman giving birth ‘forgets’ the pain, I find a new book and am inspired to begin planning another one. Practically speaking, my college operates on quarters and I most often teach these seminars in Fall and Spring – Fall because I have more energy and Spring because I want to reach out to graduating students. In a semester system, I speculate that these would be well suited for the January term.

I have also found that spending more time with students feeds itself. Seminars allow me to work with students like Harry (the chemistry turned mathematics major I mentioned earlier). Such students are a pleasure to work with on a personal and mathematical level. But building meaningful relationships through projects and in the classroom includes an inherent risk. It requires opening your heart, which includes the risk of pain. This most recent term has been especially challenging for me. I can vividly recall a young woman sitting in my office pouring out hopes and dreams only to die a few months later in an auto accident. This tragedy was on top of a former student murdering four before being killed by the police. These incidents were very difficult and sent me to repeatedly read the Book of Job. But it has also given me a stark reminder of the importance and urgency of reaching students by any means possible, including through studies in the philosophy of mathematics.

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<sup>9</sup> Evan Pfister, engineering major

<sup>10</sup> Audrey Chavarria, engineering major

<sup>11</sup> Daven Camacho, engineering major

Even with the demands and risks of conducting seminars on the philosophy of mathematics, there is no doubt in my mind that they are part of what has made me the teacher I am today. I began teaching at the ripe age of 22. I was excited about mathematics, students, and education. One of my fears was that my passion for teaching would fade when the honeymoon ended. Now after twelve years of teaching, over 100 classes, and around 3,000 students, I would say my fear was unfounded. I credit these projects for part of what has helped me grow in my passion and commitment.

While I hope that others will consider offering seminars in the philosophy of mathematics, my broader desire is that you will reflect upon those aspects of mathematics you find most intriguing and then develop ways for you to pursue truth *with* students. Too often we are beaten down by a ceaseless parade of committee meetings, too much material, too little time, and piles of exams to grade. But we are more effective as teachers when we ourselves are challenged and learning. We can motivate others when we are inspired. And working closely with students allows us to build meaningful relationships and thereby transform the lives of the next generation.