Building Long-Term Support for Faculty through Graduate Student Instructor Professional Development

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Introduction

Improving university-level instruction is an important step to improving instruction at all levels, and in order to improve university-level instruction, instructors need to master more effective models of instruction and be able to draw on education literature as they continue to develop as instructors. Well-trained, informed instructors are well equipped to be agents of change when they take on faculty positions. However, this mastery requires training and practice.

To train their graduate student instructors (GSIs), many mathematics departments have developed professional development programs. In fact, "effective training of graduate teaching assistants" was identified as one of the seven characteristics of successful calculus programs (Bressoud & Rasmussen, 2015). Several models of professional development are currently used throughout the country (Ellis, 2015). This narrative report will describe one such professional development course at the University of Nebraska-Lincoln. In addition to describing the course, this report follows the methods employed by Miller and Wakefield (2014) to describe some of the potential benefits of the course on participants by allowing them to directly voice their views within the text of this report.

Professional Development

Mathematics GSIs at the University of Nebraska-Lincoln participate in a mandatory professional development program designed to help them develop as teachers. In the first year, GSIs lead tutorial sessions for either Calculus I or Calculus II. In their second year, GSIs serve as instructors of record in either College Algebra or Intermediate Algebra while concurrently taking a one-year course called *Teaching and Learning Mathematics at the Post-Secondary Level* (TLM), which is the focus of this report. To prepare GSIs to be an instructor of record for the first time, GSIs participate in a three-day teaching orientation prior to the start of the second year and the TLM course. The major thrust of the orientation is administrative policies and basics of how the coordinated courses are structured. However, there are also specific breakout sessions devoted to lesson planning, incorporating group work, grading, types of discourse, and issues of equity.

Teaching and Learning Mathematics at the Post-Secondary Level (*TLM*) is a 3-credit course (2 credits in the fall, 1 in the spring) in which GSIs read mathematics education literature, discuss best-practices, conduct classroom observations, and write about learning and teaching mathematics. In the following subsections, we describe the major components of TLM.

Semester One (2 Credits)

The first semester of professional development aims to introduce GSIs to active learning practices and the literature in support of those practices. The course meets two days a week for an hour each day. The first semester can be broken into four units: *Setting the Stage, Our Classrooms, Assessment,* and *Our Students*.

Setting the Stage is a unit devoted to introducing GSIs to mathematics education literature and helping them think more deeply about student cognition. Several reading assignments set the stage.

The first reading assignment is *Accounting for Tutorial Teaching Assistants' Buy-In to Reform Instruction* (Goertzen, Scherr, & Elby, 2009). In their paper, Goertzen, Scherr, and Elby argue that the level to which a graduate student buys into reform instruction has a significant impact on the fidelity of implementation. In TLM, this paper serves to show GSIs how their attitude toward the active learning instructional model at Nebraska can carry into the classroom and affect the efficacy of the model. The discussion of this article concludes by asking GSIs to reflect on the question "What steps could an instructor take to ensure that their own attitudes about teaching and mathematics do not negatively impact their students learning?"

After having established the importance of buy-in, graduate students are introduced to their first model or theory of learning. *APOS: A Constructivist Theory of Learning in Undergraduate Mathematics Education Research* (Dubinsky & McDonald, 2001) provides GSIs with an explicit, accessible model that they can immediately apply to their own students. The APOS model also helps GSIs become familiar with new vocabulary, which they can use in their discussions of student learning. Most graduate students find APOS to be an interesting theory and a valuable way of thinking about their students.

GSIs are also introduced to Constructivism in order to further deepen their knowledge of student learning. In their essay *Constructivism,* Tsay and Hauk (2013) introduce the concept of constructivism and, in particular, the language of accommodation and assimilation using examples from college level introductory mathematics. This essay gives GSIs the opportunity to think more deeply about their students and see the importance of having their students construct knowledge for themselves.

Setting the Stage culminates with students writing a three- to five-page paper in response to the prompt:

> *Detail your own view of how learning occurs, how it applies to your classroom, and how it compares with constructivism. You do not have to agree with constructivism, but you do need to demonstrate that you have a working understanding of constructivism. At a minimum your paper should address issues such as: How do students in your class learn? How can you evaluate when a student has learned a topic? In your view of learning, what can you do to improve student learning? If a constructivist visited your class, how would they say that learning was occurring?*

Our Classroom is the second part of TLM. In this part of the course students begin to think about the mathematics content, active learning, and the classroom environment. Several readings are used to spark discussion.

In *Leaves and Caterpillars: The Case of David Crane,* Smith and Stein (2011) argue that carefully selecting and sequencing when and what students present to their peers is a central component of mathematical discussion. After reading Smith and Stein's narrative from an elementary classroom, GSIs are given the opportunity to look at samples of student work from Intermediate Algebra and discuss how they would select and sequence student presentations.

A major component of the mathematics content taught in both Intermediate and College Algebra at Nebraska involves solving applied problems, and in many cases, students are asked to solve these problems before

being formally "taught" the standard computations. *Mathematics in the Streets and in Schools* (Carraher, Carraher, & Schliemann, 2004) provides GSIs with evidence that the traditional method of teaching a standard algorithm and then applying that algorithm to a specific context may not be the best method for every student.

One of the most difficult topics that GSIs encounter as novice precalculus instructors is transformations of functions. Many undergraduate students struggle to understand transformations of functions in ways that most graduate students have not experienced. Reading Lage and Gaisman's (2006) article *An Analysis of Students' Ideas About Transformations of Functions* helps GSIs to recognize some of those struggles and allows the class to have meaningful discussions about a specific topic that is difficult for many instructors to teach effectively.

At this point in the semester, GSIs have been exposed to enough mathematics education research and student work that they are ready to tackle the first major project. For this assignment, GSIs are asked to collect and analyze some work from students in the courses that they are teaching, write up an analysis of some of the student difficulties, and develop a plan for helping students to overcome these difficulties[1].

In *Assessment*, GSIs are introduced to formative and summative assessment of both their students and their teaching. This section aims to foster a realization that effective teaching requires us to assess both our own teaching and our students' learning. The first major topic included in this section is course evaluations.

In *Teaching Assistants and Mid-Term Feedback from Students*, Yestness, Hauk, and Nasir (2013) address issues such as: how to improve the quality of feedback received by undergraduates on midterm evaluations, how to filter what students say when providing feedback to the instructor, and how to respond to the feedback received by students. This paper is also paired with the associated video case study from http://collegemathvideocases.org and provides GSIs with the opportunity to interpret and use mid-semester feedback in a meaningful way.

In his classic article, *Benny's Conception of Rules and Answers in IPI Mathematics*, Erlwanger (1973) brilliantly demonstrates both the dangers inherent in using summative assessment as the only means to assess student learning and the value of using qualitative data to explore student conceptions. GSIs are encouraged to critically evaluate their own assessment methods and look for ways to gain a deeper understanding of their students' conceptions.

The final component of the first semester is a section referred to as *Our Students*, which consists of an extended discussion of the people in the classroom, their needs, and how we can most effectively teach these individuals. For many GSIs, learning mathematics has always come easily and the idea of struggling with mathematics is foreign. Thus, the primary goal of this section is to help GSIs develop empathy for their students.

Mathematical Autobiography Among College Learners in the United States (Hauk, 2005) tells the mathematical story of several students. GSIs are faced with stories of students who have developed strong emotions towards mathematics. These stories help GSIs to understand that the events playing out in their classrooms may not be the result of laziness, lack of motivation, or a desire to cheat the system but rather the result of a previous experience with mathematics. Many GSIs comment that this is the most moving section of the course and has a big impact on them as mathematics instructors.

[1] For further information on this assignment and analysis of this assignment we refer the readers to (Lai, et al., 2016) and (Miller, Wakefield, & Lai, 2018).

Semester Two (1 Credit)

The second semester of TLM focuses on describing student learning, and the class meets once a week. GSIs look at definitions of some terms from a particular learning theory and then proceed to discuss how those terms can be used to describe events that are taking place in the classes that they are teaching. This semester varies from year to year in exactly what is covered, but at a minimum each of the following learning theories are discussed for at least one day, and often two: Behaviorism, Social Cognitive Theory, Information Processing, Situated Cognition, Radical Constructivism, and Social Constructivism.

The goal in the second semester is to provide GSIs with the vocabulary to describe and make sense of how students are learning in their classrooms. GSIs also observe one another teach and write an essay on their observations during this semester.

Together the first and second semester make up the 3-credit professional development course. There is much more that can be said about the course. However, it is also worth discussing how TLM impacts graduate students. To this end, two of the authors, who were graduate students in the course in different years, will discuss their experiences in the course, how they initially viewed the components of the course, and how those components impact their teaching today.

Personal Narratives

Prior to attending graduate school at the University of Nebraska-Lincoln, neither one of us had taught mathematics in a formal setting, taken a pedagogy course, or experienced active learning as a student. The TLM course helped both of us think about learning and teaching in a deeper way as we taught our own class for the first time. Below we describe our combined reflections on the components of the TLM course and how it affected us as teachers[2].

*Having a formal introduction to pedagogy was a crucial component to my evolution as a teacher. I remember being willing, but skeptical, of the reformed Precalculus courses and their focus on active learning. I had a full year of leading Calculus recitations, my students' exams scores were higher than average, and I had good evaluations. I felt as though the reformation and our pedagogy course may have been more helpful to my peers than myself. After reading Goertzen, Scherr, and Elby (2009), I had a shift in perspective about student learning and was motivated to buy-in to the goals of TLM for the benefit of my students. In conjunction with an introduction to constructivism and its role in cognitive development, I began to view learning from the perspective of the learner. I was more interested in my students' organization of mental schemes and thought processes through problem solving, rather than how I might present the material as a good speaker and lecturer.

**Our Classroom* helped me to implement active learning in my own classroom. In particular, Carraher, Carraher, and Schliemann (2004) was eye opening. Brazilian children, with little formal schooling, could demonstrate arithmetic proficiency while selling fruit in a local market despite the absence of abstract mathematical training. Their abilities strongly emphasized the importance of teaching mathematics within the setting of real-world applications and the value of students' personal interpretations of an abstract problem. This concept uniquely prepared me to teach several semesters of mathematics for pre-service primary school teachers, where the students would face the interpretive nature of their own students in the future. The students had weekly assignments that involved reasoning through classical problems like Euler's Seven Bridges of Könisberg. By encouraging original thought and productive failures, I was able to support the learning of interesting mathematics

[2] Hamidi and Uhing took turns writing the following paragraphs. An * indicates Hamidi's narrative and ** indicates Uhing's narrative.

and give future teachers several personal experiences that they can draw upon when working with their own students.

***Assessment* helped me think about how to evaluate my teaching and different ways of assessing student learning. Shortly after reading Yestness, Hauk, and Nasir (2013), Dr. Wakefield recommended that we administer mid-semester teaching assessments and gather feedback from our students about our classes. After comparing our standard departmental mid-semester assessment form with the one used by Yestness and her colleagues, I decided to modify our departmental survey to incorporate more student-centered questions. My goal in doing this was to help students reflect upon their own progress in the class as well as gather feedback on what areas of instruction I could improve upon. I have continued to use and modify this mid-semester feedback survey to help assess and improve aspects of my teaching in the courses that I teach[3].

**The next paper we read as part of *Assessment* was about Benny (Erlwanger, 1973). I remember being shocked by this paper and would categorize this as one of my most memorable experiences from TLM. Reading about Benny helped me recognize the importance of formative assessment and reiterated the need for me to talk with my students and try to understand what they are thinking. It also highlighted an advantage of using active learning methods and allowing students the opportunity to work on problems in class since I am able to walk around, look at what students are doing, and ask them questions about what they are thinking.

**During the last component of the first semester, we talked about our students. I was not surprised by the stories detailed in Hauk (2005) as I was aware of the potential for students to have pre-existing feelings about mathematics from their previous experiences. However, our conversations about this topic did reinforce the importance of considering students as individuals and trying to understand their perspectives and feelings about mathematics.

**The main emphasis of the second semester was exploring different learning theories. Reading and learning about these theories made me aware of the breadth of research that has been conducted in this area. It also helped me become more familiar with specific terminology and vocabulary that I could use to talk about learning and teaching mathematics.

**Another activity that we did as part of TLM was conduct classroom observations of both faculty members and peers. This experience allowed me to view teaching from an "objective" outside perspective and helped me to reflect upon my own teaching methods. Up until that point, I had never sat in on a class solely to observe the teaching and learning that were taking place in the classroom. Instead of focusing on the course content, I was able to think about the teaching decisions that were being made and how those affected students in the class.

TLM helped us think about how our experiences as learners should impact our teaching. Both of us came into TLM caring about teaching and thinking that we were good teachers, but TLM helped us to realize that we still had a lot to learn about pedagogy. Participating in TLM has concretely helped us to become better teachers in several ways. As a result of taking this class, we are able to interpret and evaluate how math education literature applies to our own teaching and learning. Furthermore, we have a rich teaching support network because our peers have also participated in TLM, and we have a common framework and vocabulary with which to discuss our shared teaching experiences. The knowledge we developed and the experiences we gained from TLM will continue to impact us in our careers as we teach future generations of mathematics students.

[3] Comment from Wakefield: In fact, the entire first year program and many others in the department are now using Uhing's modified version of the Mid-Semester Assessment Form.

Conclusions and Implications

The narratives in this reflection demonstrate that mathematics Ph.D. students are capable of both reading and applying mathematics education research and growing as educators through a course that utilizes research papers to drive discussion of their own classrooms. At the University of Nebraska-Lincoln, graduate students are given a single course release to allow them to participate in the course. For many institutions, course releases require a significant investment of resources. However, the Nebraska mathematics department has been pleased with the results and continues to invest in GSI professional development. Ultimately, the goal of this professional development is increased student learning, not just in the immediate future, but over the course of each graduate student's lifelong career. In these two specific cases, TLM has accomplished this goal, and we believe these two cases generalize to other graduate student instructors who have also gone through the TLM course.

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