PREPARING FUTURE PROFESSORS: HIGHLIGHTING THE IMPORTANCE OF GRADUATE STUDENT PROFESSIONAL DEVELOPMENT PROGRAMS IN CALCULUS INSTRUCTION

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This report details the importance of professional development and training for graduate student teaching assistants (GTAs) in in the teaching of calculus. Findings from a large, national study in the United States show that GTAs are teaching a large percentage of Calculus I students (either as the primary teacher or as a recitation leader), receiving widely varied preparation for this teaching, and experiencing this preparation to varying degrees of effectiveness. The results motivate the need to further investigate the current landscape of GTA professional development, and lay the groundwork for subsequent analyses to explore connections between GTA PD, instructor attributes, such as beliefs and practices, and student success.

INTRODUCTION

In this report I investigate the current state of graduate student teaching assistant (GTA) professional development (PD) programs among math departments employing GTAs in the teaching of Calculus I. In particular I examine (a) the number of Calculus I students being taught by GTAs compared to other instructor types, (b) the ways institutions are employing GTAs in the teaching of Calculus I, and (c) the frequency and effectiveness of various means of preparing and selecting GTAs for their roles in the teaching of Calculus I. Data for this study comes from a large, national study in the United States focused on successful calculus programs conducted under the auspices of the Mathematical Association of America (MAA). Initial reports from the project indicate that a number of student, instructor, and institutional characteristics appear to be associated with more successful programs, and serve as a backdrop to this study on GTAs roles in Calculus I (Bressoud, Carlson, Mesa, & Rasmussen, 2013).

Calculus I is not only an integral part of all Science, Technology, Engineering, and Mathematics (STEM) fields, but it has also been shown as a critical contributing factor in students' decisions to leave the STEM disciplines (Seymour & Hewitt, 1997). Graduate student teaching assistants contribute to calculus instruction in two ways: as the primary teacher and as recitation leaders. As the primary teacher, GTAs are completely in charge of the course, just as a lecturer or tenure-track/ tenured faculty member would be, although GTAs may lack the experience, education, or time commitment of their faculty counterparts.

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GTAs can also be viewed as the next generation of mathematics instructors. This means that in addition to their immediate contribution to the landscape of Calculus I instruction, GTAs contribute significantly to the long-term state of undergraduate mathematics instruction. The preparation GTAs receive for teaching calculus therefore influences both their immediate teaching practices as well as their long-term pedagogical behavior. There has been significant interest regarding what knowledge and experiences are needed to foster excellent (or even adequate) teachers of mathematics at the K-12 level (Ball, Thames, & Phelps, 2008; Hill, Ball, & Schilling, 2008; Shulman, 1986) and instructors at the undergraduate level (Johnson & Larsen, 2012; Wagner, Speer, & Rossa, 2007; Zazkis & Zazkis, 2011). From these investigations, it is clear that expertise in mathematics alone is not sufficient in the preparation of teachers.

Professional development efforts to improve teaching at the K-12 level are often aimed at developing teachers' knowledge, beliefs, and instructional practices in order to improve their students' success, and to enculturate new teachers into the teaching community (Putnam & Borko, 2000; Sowder, 2007). Literature surrounding GTA PD is growing, though still little is known about the current climate of GTA professional development on a national level. In this study I examine the roles and preparation of GTAs involved in the teaching of Calculus I across the US.

BACKGROUND

The National Science Board (NSB, 2008) uses the term "professional development" to refer both to teacher preparation (i.e. for preservice teachers) and to the development of practicing teachers (i.e. for in-service teachers). Graduate student teaching assistants (GTAs) have commonalities with both preservice and in-service teachers: the training they receive as GTAs is typically their first instructional training; however, they often receive this training after they have begun teaching.

The literature surrounding GTA professional development is growing as national reports point to the significance of undergraduate education, especially in preparing students in the STEM disciplines (e.g., PCAST, 2012), and as GTAs play an increasingly important role in the teaching of STEM courses (Belnap & Allred, 2009; CBMS, 2005, 2010). Preliminary results from the most recent College Board of Mathematical Sciences (CBMS) survey show that, while there is a steady increase in the number of students enrolled in introductory mathematics courses nationwide, there is a 5 percent decrease in the number of tenured and tenure-track mathematics faculty from 2005 to 2010 (Lutzer et al., 2007). The heightened instructional need is being met by an increase in the number of GTAs, postdoctoral appointments, and adjunct faculty.

Increased attention to GTA training is necessitated by the growing employment of GTAs in the teaching of undergraduate level mathematics, coupled with a number of studies pointing to GTAs' lacking Mathematical Knowledge of Teaching (MKT) (Kung, 2010; Kung & Speer, 2009; Speer, Gutmann, & Murphy, 2005) and abundantly held novice beliefs regarding the teaching and learning of mathematics (Gutmann, 2009; Hauk et al., 2009; Raychaudhuri & Hsu, 2012). Further, Speer, Strickland, and Johnson (2005) found that even experienced graduate students often lack knowledge of student learning of key ideas and have not developed strategies to support student learning of these topics. However, Kung (2010) found that it is possible for GTAs to develop rich knowledge of their students' mathematical understandings through professional development programs that emphasize student thinking.

These studies highlight a view that has become more widely accepted since first introduced by Shulman (1986): strong content knowledge alone is not sufficient for teaching mathematics, but must be accompanied by strong pedagogical knowledge and beliefs. Knowledge and beliefs about the teaching and learning of mathematics are developed through experience and professional development (Sowder, 2007). Since GTAs often lack teaching experience, these instructional qualities are fostered in GTAs primarily through professional development (Speer & Kung, 2007; Speer & Hald, 2008).

METHODS

Data for this study comes from a large-scale national survey of mainstream Calculus I, where mainstream calculus refers to the calculus course that serve as prerequisites to typical upper-division mathematical sciences courses. This study included three surveys given to students (one at the beginning of Calculus I, one at the end of Calculus I, and one a year later), two surveys given to instructors (one at the beginning of Calculus I and one at the end of Calculus I), and one survey given to the calculus Course Coordinator, who acts as a institution representative regarding departmental programs targeting GTA PD. All surveys were completed online, and no incentives were given for completing the surveys. The surveys were sent to a stratified random sample of mathematics departments following the selection criteria used by the Conference Board of Mathematical Sciences in their 2005 study (Lutzer et al, 2007). There were 14,247 students and 1,149 instructors for whom there was either start-of-term survey data, end-of-term survey data, or both. Of these, 12,383 students were matched with 648 instructors with nearly complete data. In order to provide a description of the implementation and preparation of GTAs involved in the teaching of Calculus I, I conducted descriptive analyses of collected data. In the following section I present the results of these analyses, and then conclude with a discussion of the implications of these descriptive results, as well as next steps for this research.

RESULTS

As shown in Table 1, 15.6 percent of the instructors were GTAs, 12.4 percent of all students were taught by a GTA. The percentage of students taught by a GTA increases slightly to 15.4% among students attending Ph.D.-granting institutions. In the 2005 College Board of Mathematical Sciences (CBMS) report, GTAs were determined to have taught eight percent of the 201,000 students enrolled in mainstream Calculus I and 22% of all mainstream Calculus I sections at Ph.D.-granting institutions (Lutzer et al., 2007). Thus our data set shows that GTAs are teaching a larger percentage of all mainstream Calculus I students compared to the 2005 CBMS but a smaller percentage of students at Ph.D.-granting institutions.

Table 1 also shows that while the largest numbers of instructors were tenured faculty (33%) or other full time faculty (26%), other full time faculty taught the largest percentage of students (43%). In this study, other full time faculty include adjunct faculty, lecturers with security of employment, and non-tenure track teaching professors. This result shows that GTAs comprise a substantial percentage of Calculus I instructors and teach a substantial percentage of Calculus I students. In fact, GTAs comprise a larger percentage of Calculus I instructors and teach a larger percentage of Calculus I students than tenure-track faculty. In these frequencies, GTAs are the instructor on record. In this next analysis, I account for GTAs that led recitations.

Instructor Status	# Instructors	Percent	# Students	Percent
Tenure-track faculty	93	14.4	1373	11.1
Tenured faculty	215	33.2	3397	27.4
Other full-time faculty	170	26.2	5323	43.0
Part-time faculty	57	8.8	503	4.1
GTA	101	15.6	1540	12.4
Visiting/ Post-doc	12	1.9	247	2.0
Total	648	100	12,383	100

Table 1: The number of instructors and students taught by them, by instructor status.

As shown in Table 2, graduate students were employed by 62 institutions of the 65 Doctoral granting institutions involved in the study. Of these, 46.8% employed GTAs as the primary instructor for a Calculus I course only, 53.2% employed GTAs as recitation leaders only, and the remaining 19.4% employed GTAs both as primary instructors and as recitation leaders. Together these results show that GTAs are widely utilized by Doctoral granting institutions both as recitation leaders and as the primary instructor in Calculus I. This wide utilization leads one to ask in what ways GTAs are being selected or prepared for these roles – the following analysis answers this question.

Utilization of GTAs	Number of Institutions	Percent of institutions employing GTAs
GTAs lead recitation only	33	53.2
GTAs teach their own section only	12	19.4
GTAs do both	17	27.4
Total	62	100.0

Table 2: Number of institutions utilizing GTAs.

At these 62 institutions that utilize GTAs in some capacity, various practices geared toward the selection or preparation of GTAs were used, and to varying degrees of effectiveness. Table 3 shows that the most common programs for selecting or preparing GTAs are a seminar or class for the purpose of GTAs' professional development, some form of screening GTAs prior to assigning them to a recitation section, and faculty observation of GTAs for the purpose of evaluating their teaching, with over 70% of institutions using each of these methods for preparing their GTAs. Among the institutions utilizing these preparation/ selection methods, at least 70% of institutions said they were effective, with 83% saying that the seminar or class was effective.

Table 3 also shows that about half of the institutions have a program that pairs new GTAs with a faculty member, but only about 60% of these programs were said to be very effective or effective by the Course Coordinator. Additionally, about 40% of institutions have some other program for GTA mentoring or professional development, with 70% of these identified as effective. Research on K-12 professional development points to the important role that mentoring plays in teacher preparation, specifically in increasing teacher effectiveness and decreasing teacher attrition (Putnam & Borko, 2000; Sowder, 2007). However, without knowing the nature of the mentorship at these institutions is difficult to understand what role this played in GTA preparation.

GTA selection or preparation activity	Institutions	% institutions employing GTAs	% effective
Seminar or class for the purpose of GTAs professional development	47	75.8	83.0
Faculty observation of GTAs for the purpose of evaluating their teaching	47	75.8	70.2
Screen GTAs before assigning them to a recitation section	44	71.0	70.5
Pairs new GTAs with faculty members	33	53.2	60.6
Other program for GTA mentoring or professional development	27	43.5	70.4
Interview process to select prospective GTAs	21	33.9	76.2

Table 3: Frequency and effectiveness of activities to select or prepare GTAs from national sample.

DISCUSSION

These survey results call for more research into the connections between GTA preparation and instructor and student success, and lay the foundation for this work. This analysis is the beginning of a larger project that draws on the survey data described above, as well as explanatory case studies (Yin, 2003) conducted at five doctoral granting institutions determined to be more successful than other institutions. Success was defined as a combination of student variables: persistence in Calculus as marked by stated intention to take Calculus II; affective changes, including enjoyment of mathematics, confidence in mathematical ability, interest to continue studying math; and passing rates. As part of the case studies we interviewed students, instructors, GTAs, GTA trainers, Course Coordinators, and administrators, observed classes; observed GTA training, and collected GTA training material, exams, course materials, and homework. Additionally, a follow up survey, in which GTAs were asked to describe and evaluate their preparation to teach, as well as answer questions regarding their beliefs about teaching mathematics, was sent to all current GTAs at the five selected institutions. Initial analyses of this multimodal data set point to a strong connection between student persistence in the calculus sequence and instruction by a GTA (Rasmussen, Ellis, & Bressoud, 2013). However, among the five successful institutions with high student persistence, GTAs received extensive preparation for their roles in teaching Calculus I (Rasmussen, Hsu, Burn, & Melhuish, 2013). Together, these results suggest a relationship between GTA PD and student success that needs to be further examined.

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