Working Group for Research About Novice Teachers of College Mathematics: Report from our Convening at the 2009 RUME Conference

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Purposes of the Group

The training or professional development of graduate students and beginning faculty as teachers has become an increasingly visible topic in the mathematics community over the past three decades (Speer, Gutmann, & Murphy, 2005; Speer, Murphy, & Gutmann, in press). Furthermore, an increasing number of individuals have been pursuing research in this area. However, because this area is young and many of the researchers are also early in their careers, there has been a need for a venue in which researchers could interact with others interested in this area and also provide and receive feedback on developing ideas. These needs were left unfilled by existing conference structures so we created a working group for those who share this research interest.

The working group pursues three primary goals: (a) to provide critical, informed support and feedback for researchers conducting research on or about novice teachers of college mathematics (NT-CM); (b) to help mathematics educators interested in the experience of NT-CMs and NT-CM professional development connect and collaborate; (c) to consider over-arching issues related to individual research agendas and to endeavor to contribute to these common concerns. This group first convened at the 2002 Psychology of Mathematics Education – North American Chapter (PME-NA) conference. Meetings have occurred approximately every

year since then. This is the first convening of the group in conjunction with the RUME conference. In this paper we describe the structure of the working group and provide progress reports on the research ideas presented during the working group session.

Convening of the Group at RUME 2009

Participants were recruited via email invitations to various listservs. Participants submitted proposals that included a description of their project, a plan for how they would spend their allotted time during the meeting, and a description of what they hoped to get out of the group's discussion of their project. The working group convened for six hours prior to the official start of the RUME conference. During the meeting, nine participants shared information about the research projects that they were planning or were in the midst of working on – work that was in a stage too early to present in a regular conference session. In addition to the nine researchers who were seeking feedback on their projects, 12 people attended the working group, including the two organizers. The group discussed each project and provided the presenter with feedback on their ideas and plans. Below are the presenters' summaries of their projects.

Project Summaries

Mathematical Knowledge for Teaching: A Case of Mathematics Teaching Assistants

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Teaching mathematics not only necessitates knowledge of the subject matter, but also knowledge of pedagogy and student learning. Despite significant research related to K-12 teachers'

mathematical knowledge (Ball, Lubienski, & Mewborn, 2001; Fennema & Franke, 1992; Ma, 1999; Munby, Russell, & Martin, 2001; Shulman, 1986, 1991) there has been little research regarding collegiate-level mathematics instructors' mathematical knowledge for teaching (Speer et al, 2005; Speer, Strickland, Johnson, & Gucler, 2006). At the university level, mathematics graduate students are often appointed as instructors for many foundational undergraduate mathematics courses. These mathematics teaching assistants (M-TAs) generally have few opportunities to discuss issues of pedagogy and student thinking and their relationships to student learning, which are key aspects of mathematical knowledge needed for teaching. Examining the mathematical knowledge for teaching (MKT) of M-TAs could provide insights into what they know and need to know to be effective teachers and how to support them in their teaching.

This qualitative case study investigated the MKT about the derivative of two M-TAs who were sole instructors of *Survey of Calculus* courses. Through classroom observations and semi-structured interviews, this research focused on the following questions: (a) how did the M-TAs prepare for, teach, and reflect on lessons related to the derivative concept? (b) How was the M-TAs' mathematical knowledge for teaching the derivative expressed in their teaching practices? Together, these two research questions provide some insight regarding to what extent the MKT framework was useful in characterizing knowledge that M-TAs draw upon in their teaching practices around the derivative concept. During the CRUME 2009, this project was in the analysis stages; feedback from the working group provided guidance for the analysis. The methods used to examine the M-TAs' teaching practices, to study their MKT, will inform my future research strategies and subsequent investigations of MKT at the collegiate level.

Ascertaining the Professional Development Needs of Graduate Mathematics Teaching Assistants

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Graduate mathematics teaching assistants (GMTAs) play a significant role in undergraduate mathematics instruction (Belnap & Allred, 2006). Most departments provide GMTAs with formal professional development; many program facilitators have posed critical questions to researchers (Belnap & Allred, 2006), including: How much preparation is needed? What specific content should be provided? and What activities are most effective?

This project is an initial effort to address these questions, by establishing a research base for decisions regarding the content and trajectory of GMTA professional development programs. To do so, I am using data from three research studies: the GMTA Context study (2002-2003), the Video Observations with Peer- feedback Sessions (VOPS) study (2006-2009), and the Cases study (2007-2009). The yearlong GMTA Context study (Belnap, 2005) investigated GMTAs' experiences as they learned to teach on-the-job and how these experiences related to the professional development that their departments provided. Participants represented GMTAs with a variety of teaching backgrounds, research interests, and experience as GMTAs. Data from this study consist of transcripts from several semi-structured interviews aimed at capturing details of each participant's experience prior to and throughout the year.

The VOPS study (Belnap & Withers, 2008, 2009) investigates one department's program, in which participants engage in discussions regarding teaching, catalyzed by video footage taken from their current classroom instruction. Participants' assignments and responsibilities have been diverse, but consistent and typical of GMTAs in U.S. mathematics departments (Belnap &

Allred, 2006). Participants' backgrounds were atypical for GMTAs, in that all had prior degrees in education and prior teaching experience (most at the K-12 level). Data from this study include: (a) transcripts and video of the weekly VOPS, (b) transcripts and audio from each year's exit interviews, and (c) brief post-session reflection writing.

Similar to the VOPS study, the ongoing Cases study investigates a program in which participants engage in discussions regarding teaching, catalyzed by the case studies from Friedburg et al. (2001). Participants' assignments and responsibilities have also been diverse (but typical); however, their degrees were in mathematics and they had no prior teaching experience. Data from this study include: (a) transcripts and video of the weekly discussions, and (b) brief post-session reflection writing.

Using these data, I am identifying evidence of GMTAs' professional development needs. This includes those: (a) explicitly stated, (b) implicitly evidenced, (c) fulfilled, and (d) unmet. Through grounded theory techniques (Strauss & Corbin, 1998), I am conceptualizing and distilling these into a collection of topics and trajectories representing the data, which will show program developers what programs could address if they wish to meet participants' needs.

Examining Novice College Mathematics Instructors' Mathematical Conceptions and Teaching Practices

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This is an ongoing study on mathematics graduate teaching Assistants' (TAs') conceptions of mathematics in general and algebra in particular, their mathematics learning experiences, and the

relations of such conceptions and experiences to the TAs' current practices in teaching algebra.

The researcher administered a questionnaire to 20 mathematics graduate TAs on their academic backgrounds and conceptions of mathematics, then selected eight TAs with different backgrounds and observed three consecutive sessions taught by each of them. Shortly after the observations, the researcher conducted an hour-long, semi-structured interview with each TA to discuss (a) what has shaped his or her teaching style, (b) a few specific scenarios in the three observed lessons and the TA's thinking and reasoning in each scenario, and (c) his or her conceptions of the course, student characteristics, and issues in algebra teaching and learning.

Preliminary data analysis shows that the TAs either hold a polarized view on the nature of algebra (as a set of basic skills versus as application and problem solving), or tend to characterize algebra as a mix of various topics and activities (e.g., "generating structures," "functions," "equations," "rules," "logical thinking," "solving problems," "relationships.") Most TAs attributed successful algebra teaching and learning to practice and strengthening basic skills. Cultural backgrounds and past learning experiences explained partially the differences in the TAs' teaching styles. For instance, several of the American TAs believed that group work and interactive environment were key to students' success in learning mathematics. They intentionally organized classroom teaching in those ways. In contrast, several of the international TAs had learned mathematics through straight lecturing and in abstract approaches. Correspondingly, they preferred to teach by lecturing and felt challenged in the real-world applications of algebra. No obvious correlations were found between the TAs' conceptions of algebra and teaching styles.

Assessment & Evaluation Center for the Inquiry-Based Learning (IBL) Mathematics Project

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Our work on novice mathematics instructors is part of a large educational evaluation study of several inquiry-based learning (IBL) mathematics courses at four research mathematics departments. The mixed-methods design focuses on student outcomes—changes in learning, attitudes, beliefs, career and education interests. However, instructors—including faculty, postdocs, and graduate student teaching assistants—are important in understanding the classroom experience of students and explaining the outcomes of IBL courses for students. They are also of interest in their own right, as IBL teaching experiences appear to have a powerful impact in shaping instructors' ideas about teaching and learning, especially for instructors early in their careers.

We are undertaking an ethnographic interview study to address questions such as:

1. Who is drawn to IBL teaching, how, and why? What beliefs about teaching and learning do IBL instructors hold, and how do those beliefs evolve upon IBL experience?
2. How does an IBL teaching experience influence the development of early-career instructors (grad students, postdocs, new faculty) as teachers?
3. What skills, knowledge or traits are needed to be an effective IBL teacher, and how do these differ from the requirements of other teaching styles? What particular challenges do IBL teachers face?
4. What how-to advice can be distilled from experienced instructors' accounts for others trying IBL for the first time?

5. What disciplinary paradigms or schemas shape teaching in mathematics, and how these may be challenged or supported by IBL approaches?
6. What is particular about learning to teach mathematics vs. learning to teach in other STEM fields?

As a comparison group for the latter questions, we will draw on our group's prior work on instructional change among science faculty and graduate student TAs.

Studying the Effectiveness of Professional Development

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One aspect of my current position is the coordination of the professional development of the Graduate Teaching Assistants (GTAs) in the Department of Mathematics at WVU. While I enjoy coordinating each meeting and facilitating discussions or activities, I want to ensure that the training program I put together for these GTAs is not just enjoyable but also beneficial to their development as instructors of undergraduate mathematics.

One research question I would like to address in the near future while coordinating and revising the current training program is the effectiveness of the program. I am interested in methods of assessing the impact of professional development programs of instructors of collegiate mathematics. The impact could be measured on very specific topics (i.e. grading practices (see below), types of questions asked in class, etc.) or an overall assessment of the entire program, or somewhere in the middle.

During the working group meeting at CRUME, some suggestions I received from others at the meeting regarding this research question included before and after studies of concrete topics like the grading practices of the GTAs, specifically having them create rubrics for each other to use, or interviewing them while grading at different times during the semester. It was also mentioned that

the current set up of two groups of GTAs attending the training at different times may allow for studying the group dynamics and the different make-up of each group (experienced vs. inexperienced GTAs) may lead to interesting differences in the roles that GTAs take on while discussing issues related to teaching.

Teaching Math Majors to Teach

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We report on preliminary work with undergraduate mathematics majors at a research-one university; the undergraduate students helped to teach an outreach and enrichment program for high school students. We were interested in how first time teaching affected the beliefs, attitudes, and knowledge of those with significant mathematical background but little or no pedagogical training. During the pilot year, we found that the undergraduate participants were uniformly surprised that teaching requires mathematical and pedagogical foresight. Additionally, while they were curious about techniques such as group work, in practice, the participants were hesitant to use them out of lack of confidence. Our data, obtained through qualitative methods, suggest some potential priorities for initial work with undergraduates as teachers, and has implications on sequencing TA training programs to support a productive trajectory for novice graduate student instructors.

Case Studies in College Algebra Teaching

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Graduate teaching assistants (GTAs) and adjuncts are an important part of undergraduate mathematics education at many colleges and universities. With the current economic downturn, administrators are looking for ways to cut costs with the least impact on student learning. Hiring freezes and layoffs are happening throughout the country. Mathematics departments may be turning more and more to GTAs and adjuncts to teach introductory courses.

The proposed project is to develop new training materials for novice teachers of college algebra designed specifically for their role as educators. Beginning in the fall semester of 2002, GTAs in the math department at Pittsburg State University have submitted journal entries about their teaching experiences for the course MATH 871 Teaching Mathematics. The current project is to prepare case studies based on real teaching situations for use in training new teachers at PSU and for publication. Information gleaned from seven years of journal entries will be the basis of the case studies. After sorting and organizing the writings it will be necessary to identify teaching situations and common threads of concerns. Then, relevant and discipline-specific cases will be written to help prepare GTAs and adjuncts for the unique challenges and limitations they face as novice teachers. The goal is that the cases raise a variety of pedagogical and communication issues to be explored through group discussion and analysis. The case studies developed in this project have the potential to be a significant component of programs for new teachers of college algebra not only at PSU, but other universities as well. The beneficiaries of

this project are both the novice teachers and the hundreds of undergraduate students they teach each semester.

Mathematics Teaching Assistants in the Fire:

The Nexus of Love, Lust and Potential Sexual Harassment

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In a climate where instances of sexual harassment are prevalent and fraternization between MTAs and students and MTAs and faculty is common, the chances of MTAs either being sexually harassed or serving as claim handlers is extremely high. The paper in preparation that was discussed at the working group meeting defines consensual amorous relationships, sexual harassment and stalking – the three related issues commonly faced by MTAs and beginning faculty.

Drawing on MTA journals and conversations with MTAs and faculty for the past fifteen years, nine shareable case stories have been developed to help MTAs vicariously experience the complexities involved with sexual harassment and how circumstances can become easily entwined. To address the concerns raised during the working group discussion, the set of stories now includes three gender-neutral case stories and a non-omniscient *he said, she said* story all of which still have fidelity to the original stories related to the author. These stories are designed to proactively engage MTAs in thinking about the potential ramifications of such complex teacher-student relationships especially with an imbalance of power.

The final section of the paper, suggested by the working group, addresses a checklist of who and what MTAs need to know if a complainant approaches them. Specifically, the general

responsibilities of an MTA, as a claim handler in the midst of a sexual harassment allegation, is addressed as well as specific recommendations for informal claim and formal complaints against you as an MTA. In doing so, this paper has provided glimpses into an uncomfortable world that few MTAs and faculty wish to discuss. However, only through discussion and prior planning will MTAs be prepared to address the challenges that they potentially face as an MTA or a future faculty member.

Video Cases for the Professional Development of Novice College Mathematics Instructors

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The case project goal is to create, hone, and disseminate a research-informed book and digital video disk (DVD) package of materials for college mathematics teaching professional development. Video case materials are being developed from a firm foundation of existing theory, emerging research, and best practices in college mathematics instructor development. In addition to video of experienced and novice college instructors during teaching and office hours, we have conducted focus group interviews with students and have gathered interview and video observation data among graduate teaching assistants regarding the development of their pedagogical content knowledge for mathematics instruction. Field-testing and feedback on case materials will continue for another year. Materials are revised after each round of feedback.

The video and activities in the final product will consist of at least ten cases based on professionally edited video vignettes captured from college mathematics classrooms, computer labs, office hours, tutoring sessions, and group discussions. Cases illustrate situations that

include students working on and thinking about mathematics, teaching approaches common to novice and experienced instructors, strategies for effective communication, and exploration of the challenges of teaching. To date, cases developed include the topics: a) asking good questions; b) calculus learning; c) proof by math induction; d) communication about grades and grading; e) inquiry teaching methods; and f) group work. Additionally, we have completed drafts of six of the ten essays for the book.

The book-DVD will provide video vignettes of college mathematics teaching and learning along with activities based on the videos, information on theory, essays on ways research can inform and frame practice, and other resources for college mathematics instructor professional development. The tools in the book-DVD may be used as a core for college mathematics professional development programs or as a part of an already established program.

Conclusion

While we were optimistic that this experimental working group would attract interest, we were delighted by the actual response. The presenters unanimously said that the feedback was useful; the participants who did not present were glad to see what was in progress at the cutting edge of the field and to interact with other people whose specific interests aligned with their own. Several of the participants are contributors to a forthcoming issue of *Studies in Graduate and Professional Student Development.* The issue is focused on mathematics graduate student instructors and many of the articles report on projects that were discussed at previous meetings of the working group. We anticipate that the projects discussed at this year's meeting will also find their way to more formal and public venues in the future. We look forward to what the

mathematics community will learn about novice teachers of college mathematics as this area of research continues to advance and expand.

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