Novice College Mathematics Instructors' Teaching Preparation and Teaching Activities

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Abstract

This report presents a mixed-methods study investigating college mathematics instructors' (CMIs') perceptions of teaching. As part of a multi-year research and development project on CMI experiences, a web-based College Mathematics Instructor Professional Development Questionnaire (Hauk, Speer, Kung, & Tsay, 2006) was administered. Invitations to were disseminated to all instructors and teaching assistants at the top 100 Ph.D.-granting mathematics departments in the U.S. The purpose of this report is to explore novice CMIs self-reporting on three of the sub-constructs in the survey: teaching experience, teaching preparation, and teaching activities. In addition to the quantitative analysis, qualitative data from interviews with novice CMIs about the three constructs are reported.

Key words: College Mathematics Instructors, Graduate Teaching Assistants, Professional Development, Prepared, Important

Introduction

The academy anticipates a considerable number of tenured professors to retire by 2020 along with a continued trend of higher expectations for teaching quality among newly hired faculty (Adams, 2002; Austin, 2002). As the quality of teaching continues to be scrutinized, the nature of professional development and the nature of knowledge for teaching college mathematics has become the focus of many researchers (Belnap & Withers, 2009; Deshler, 2009; Hauk, Mendoza-Spencer, & Toney, 2009; Jones & Brockman, 2009; Speer, Gutman, & Murphy, 2005; Speer & Murphy, 2009). Professional development (PD) or preparation for CMIs is a relatively new area of research (Carroll, 1980; Shannon, Twale, & Moore 1998; Zuber-Skerrirr, 1992). Speer and Murphy, (2009) emphatically stated: "this area is young and many of the researchers are also early in their careers" (p. 1). With PD being a young field, those who advocate PD for CMIs and GTAs, have a substantial amount of research to collect and above all, implement.

There are many aspects with respect to preparing CMIs to teach, for example, *when* to offer PD, *how* PD is offered, *what* content to include, and *how* training should be evaluated (Shannon et al., 1998). Since there are many tenets to being a CMI, a definition for PD is a difficult one. Therefore, current research has yet to define PD or teaching preparation at the collegiate level universally. Specifically, this study will investigate CMIs' self-reported perspectives of teaching activities related to how prepared they feel and how important these activities are.

The foundation of developing and implementing PD for CMI requires an enhanced understanding of the needs of this population. CMIs come into mathematics departments and little is known about their values with respect to teaching, if they find teaching activities important, and the nature of their previous teaching experience. Current research recognizes the needs for PD (Hauk et al., 2006), reports methods of PD (Belnap & Wither, 2009; Jones & Brockman, 2009), and an even smaller domain report effects of PD with regard to student achievement (Seymor et al., 2005). With that said, current research appears to be missing a fundamental understanding of what CMIs teaching philosophies are with regarding to their values about the importance of teaching activities and their perceptions of their own teaching preparation (Speer, 2001). The overall understanding of how CMIs feel about their teaching at a basic level will assist in future PD methods and enhance understanding of CMIs enculturation into teaching in mathematic departments in the U.S.

Definitions

The population of CMIs includes any mathematics instructors with a master's degree and/or Ph.D. who are hired solely for adjunct teaching and full-time lecturing positions. These instructors are not on tenured track positions with the university where they are contracted to teach. Also for this research, graduate teaching assistants (GTAs) will also be considered novice CMIs. Although GTAs can be assigned to an array of departmental activities (e.g. recitation instructor, grader, instructor of record, or classroom assistant), this survey is designed to distill characteristics of anyone who teaches college mathematics courses (Shannon et al., 1998). Furthermore, the term *teach* will be defined to be inclusive of any activity as instructor-of-record or any form of teaching assistant and *professional development* is any activity with the purpose of improving teaching.

Literature Review

For many years, members of the academy have expressed concern about "graduate student assistants who have been handed a book, sometimes a schedule, and then waved good-bye until grades are turned in, or until adverse complaint force further supervision" (Shana'a, 1965, p. 768). This concern is still prevalent in general education mathematics classrooms (Belnap & Withers, 2009; Hauk et al., 2006; Pruitt-Logan et al., 2002; Shannon et al., 1998). Although this form of preparedness for CMIs is one of the most truthful portraits of novice CMIs, there is a negligible amount of information about the previous teaching experiences of CMIs as well as how CMI's value teaching preparation.

Novice CMIs are often assigned to teach mathematics courses with little or no guidance (Childs, 2008; Dalgaard, 1982; Seymour et al., 2005; Shannon, Twale, & Moore, 1998). The professional development CMIs receive is usually more about institutional and departmental policies than about pedagogy (Shannon et al., 1998). While teaching has become more important to mathematics departments, GTAs are getting mixed messages (Austin, 2002) from the academy. That is, GTAs are teaching one or two classes a semester but are told to focus on their studies, even if as a result their teaching falls to the wayside.

In Friedberg's 2001 book, he explains:

> The primary task of a mathematics graduate student is to learn, and ultimately create, mathematics. Most graduate school faculty, and this author, would heartily agree. But such an individual, upon graduation and being hired as a mathematics assistant professor somewhere, will be asked to teach college mathematics (p. 1).

Teaching, however, often becomes less important than class work, research, and other professional activities increase (Herzig, 2004a; Hauk, Mendoza-Spencer, & Toney, 2009; Zucker, 1996).

While teaching has become more important to mathematics departments, the academy is not preparing GTAs to be in the classroom other than their own content and syntactic knowledge

(Hauk et al., 2006). Because Bass (1997) believes communication skills are necessary to teach, it is important to note that CMIs may know the mathematics, but they do not how to communicate the mathematics to a population other than peers and professors.

I agree with Adams (2002) when he said, "students need to be introduced to new pedagogies, becoming involved with and knowledgeable about such areas as active learning, field-based learning, diversity, and technology" (p. 4). The foundation of professional development research is analyzing the current conditions of PD and CMIs perceptions and important of teaching activities. "We are instruction rich and data poor" (Carroll, 1980). Although Carroll was reporting on the effects of professional development on students' success, the data is also meager when it comes to instructors' perception of teaching practices in the classroom. Another aspect to consider is that quantitative data is also missing from the literature. As PD becomes more essential to CMIs development as instructors, it is still unclear whether CMIs preparation for being in the classroom related to their thoughts of importance of that same preparation. Authors, such as Belnap and Allred (2009), believe large assumptions have been made when it comes to PD. Assumptions are made that PD is easy and can be transferred from one mathematics department to the next. In addition, researchers not always accounted for the individual departments' needs. With the CMI inquiry disseminated across the US, I hope to gain a better understanding of the needs of CMIs with regard to their perceptions of teaching activities and how they report they are prepared and how these teaching activities are important to them. The research questions for this survey-based study are: What is the nature of respondents' experience (1) as a college mathematics instructor, (2) in their personal preparation for teaching, and (3) of professional development? Moreover, what are the relationships among teaching, preparation, and professional development?

Methods

The research approach is primarily a non-experimental, needs-assessment questionnaire for professional development. I used the web-based *College Mathematics Instructor Professional Development Questionnaire* [CMI Inquiry] (Hauk, Speer, Kung, & Tsay, 2006) to conduct this research and gathers instructors' perceptions of their preparation and the importance of teaching activities. Data collected from CMIs across the US and was analyzed using factor and correlations.

For this research, I was interested in the independent variables of teaching activities dependent on CMIs how they felt about said activities with respect to importance and preparedness to conduct these teaching activities.

Participants

Indentifying potential participants was initially completed using the American Mathematical Society (AMS) webpage. The *Updated Annual Groupings of Departments* categorizes U.S. mathematics departments with respect to degrees offered and highest mathematics degree offered. The population chosen for this study were the top 100 Ph.D. math-granting departments in the country (according to the American Mathematical Society's ranking of departments). These departments are classified as Group I, Group II, and Group III. Although there are several other Groups in this annual report, they are not of interest to this research since they do not offer Ph.D.s in mathematics.

Dissemination

The participants for this study are CMIs who were initially solicited through emails through their department chairs and/or course coordinators at their respective universities or colleges. Once the email was received by the department opinion leaders (Rogers, 2003), they were then asked to sent out to all CMIs in the department. Opinion leaders are the individuals who are able to influence others actions or attitudes. This is a natural hierarchical aspect of academia and therefore led to little or no bias. During the time of development of the survey instrument, as an intern and graduate assistant, I was one of the members who announced the survey to as many people as we could at several conferences (CRUME 2007, CRUME 2008, CRUME 2009) as a form of pre-notification. The researchers for the larger study considered this most effective so when the email did come to them in the future, they would be aware of the research, the people who were sending the survey, and their need for volunteering.

Sampling

The sampling method chosen was essentially snowballing (Patton, 2002), which entails asking one or more people to participate in the current research and in turn the current participants then ask peers or others they feel would be appropriate for the study to participate. There is one clear limitation with this method. First, the AMS website may be creditable but may not be complete. In the interest of time and dissemination, the AMS site was not compared to other references with data or statistics relative to mathematics departments in the US. The first iteration of intended participants was national. With the self-selection from department chairs it was challenging to account for all potential participants. Therefore, follow-up was inevitably non-existent other than sending out numerous emails to the opinion leaders asking for participation once again. Although respondents ranged across the country, I was still unable to gather descriptive statistics relative to state locations, college location, or department composition or location. The generalization seems to be random as all Ph.D.-granting mathematics departments were notified and equal chance of being selected.

As web-based research is a new phenomenon to academia, there is a great deal of research being conducted to compare paper, mail, email, and web-based surveys to consider response rated and costs (Heerwegh & Loosveldt, 2008; Sax, Gilmartin, Lee, & Hagedorn, 2008; Sills & Chunyan, 2002). While Heerwegh & Loosveldt (2008) debate whether their research is generalizable to a larger population than students, this is the exact population I am investigating. Therefore, the generalizability is more suitable than they proposed for this research. Also, Sax et al. (2008) confirmed that web-based surveys have a higher response rate.

After one email and one week, the number of participants for this study was n=463. Since the potential population is unclear and the response rate is non-calculable, this was sufficient for the exploratory factor analysis intended for the research.

Instrument

The data source was a web-based survey identified as the *College Mathematics Instructor Professional Development Questionnaire* [CMI Inquiry]. The web-based survey software, Survey Monkey, which allows professionals to create and publish surveys, was used to administer the survey. The FIPSE (Fund for the Improvement of Postsecondary Education): CMI Inquiry is a survey instrument developed using the 2000 National Survey of Science and Mathematics Education Mathematics Teacher Questionnaire as a foundation. The original developers, Horizon Research, Inc., had an intended audience of K-12 mathematics teachers. The intended audience for the CMI Inquiry survey was CMIs. The Science and Mathematics Teacher Questionnaires were administered to grades K-12 science and mathematics teachers. Items ask about teacher opinions, teacher background (including coursework and professional development), information about science and mathematics classes taught, detailed information about a randomly selected class, including objectives and instructional activities, and teacher demographics.

The survey has 29 overarching questions and each questions had multiple subsection. The majority of the questions were in the form of a 5-point Likert-scale. There are several scales used in the survey (e.g. strongly disagree, disagree, agree, strongly agree, no opinion and not adequately prepared, somewhat prepared, fairly well prepared, very well prepared, and no opinion). The survey questions range from the importance and preparedness of teaching activities for CMIs, classes they teach, years of experience, and supervisors' role with regard to professional development. While the majority of this survey is descriptive, the goal of this research is to analyze the factors that contribute to the value or beliefs of professional development.

Results

Though pilot work in 2008 (n=70) suggested the instrument was reliable, I will use factor analysis and Cronbach's alpha for additional tests of the reliability and internal validity of the instrument. As of this research, I did not have data from which to speculate on the results. The pilot work among a mixed group of CMIs, many with mathematics education research background, involved a significantly different population from that of the Fall 2009 administration of the survey (taken by those aiming for a research mathematics career) that I also may have an opportunity to compare the experiences, perceptions, and self-reports about teaching between the two populations.

Teaching positioned ranged from tenured or tenured track faculty, graduate teaching assistants, part-time, adjunct instructors, and other. Forty-five percent of the respondents were graduate teaching assistant, 31 percent part-time/adjunct instructors, 24 percent tenured/tenured track faculty. While college and universities have different hierarchies for their instructors, Research I institutions (http://www.usnews.com/) tend to encompass these categories of instructors. With that said, the population of respondents was n=462, but with missing data, an n=388 was used for the exploratory factor analysis.

I indented this research be a preliminary report and I participated in the Working Group for Research about Novice Teachers of College Mathematics [CMIWG] (Speer & Murphey, 2010), therefore complete results were not reported at the CRUME 2010. I did report on an exploratory factor analysis I conducted on the two questions related to teaching activities. From interactions among the CMIWG, I became more aware of the issues other researchers were considering. Although I conducted an exploratory factor analysis for reliability and factor loadings, on two questions, the group was more interested in correlations between the two topics regarding teaching activities. Since I did not calculate the correlation between the importance of preparing for all types of instructors or the separate instructors, I was only able to report the three loadings factors for each question.

Exploratory Factor Analysis

I conducted an exploratory factor analysis on the two questions relative to importance and preparedness for conducting teaching activities. Each of the questions had 14 sub-questions (Appendix A). There were three factors apparent in the factor loadings in the analysis. Those loadings were similar for each of the questions. That is, there was a relationship between whether CMIs felt prepared to teach specific activities as well as prepared for teaching those activities. Table 1 illustrates the three factor loadings.

Table 1

Factor Loadings for Teaching Activities

Calculators $\alpha = 0.893$	9	Technology $\alpha = 0.889$	9	Graphing calculators- Assignments
	10		10	Graphing calculators- Exams
	8		8	Graphing calculators- Demonstrate ideas in class
	11[a]		11	Have students use computers
Applications $\alpha = 0.740$	4	Application $\alpha = 0.794$	4	Provide examples of explicit connections between mathematics and other disciplines
	1		1	Provide concrete experience/examples before introducing abstract concepts
	12		12	Students apply math to solve problems in a variety of real-world and abstract contexts
	2		2	Prior understanding of math into account when planning and preparing for instruction
	14[a]		14	Use concept-based assessment
			3	Practice computational skills and algorithms
Group Learning $\alpha = 0.611$	6	Group Learning $\alpha = 0.845$	6	Collaborative learning
	5		5	Cooperative Learning
	7		7	Students prepare projects, labs, &/o reports
	13[a]		13[a]	Use performance-based assessment

[a] Factor did not load

After I identified the three factors for these questions, I was able to conduct a correlation between the two main tenets of interest. The correlation showed that if CMIs felt prepared to teach a class activity, they felt the activity was more important (R-value of 0.33). Since I was unable to determine causation, due to the design of the survey instrument and lack of treatment prior to the survey, it is still important to discover the future PD can be designed around the values of CMIs. For example, if a CMI believes technology is important in the classroom, PD can then be related to preparing CMIs to develop skills around technology.

Qualitative Connections

With the results from the qualitative study I have been a part of (Hauk, Mendoza-Spencer, & Toney, 2009), there was a disconnect between the CMIs we interviewed with respect to how well prepared they felt to conduct teaching activities and how important they felt these teaching activities were to them. That is, Miranda felt prepared for teaching because she participated in lesson studies during her first year as a graduate teaching assistant. Although she reported participating in lesson studies, she did not report using these lessons into her classroom, other that the times she was required to use the lessons by her course coordinator. In addition, Eve considered conducting group work in her classroom, but she did not feel prepared and was afraid of messing the process up. That is, she was concerned with: "What happens if it doesn't work? What do you tell the students? What are the *students* thinking?" (Hauk, Mendoza-Spencer, Toney, 2009). This is yet another illustration that CMIs may find teaching activities important but they do not feel prepared to conduct these activities in the classroom.

Questions for future research

The results reported are of a preliminary nature and therefore not complete with regard to the qualitative integrations of the current findings. I will attempt to continue this study by conducting follow-up semi-structured interviews (Patton, 2002) with the participants from the CMI Inquiry to gain a deeper understanding for CMIs' feelings regarding how prepared and how important teaching activities. How might the relationships among teaching experience, personal planning for instruction, and professional development inform professional development for CMIs?

1. What form(s) of additional mixed methods research data collection and analyses would be the best next steps to inquire about the efficacy of different kinds of professional development for novice, mid-career, and experienced CMIs?
2. What is the nature of pedagogical content knowledge preparation effect on perception of preparedness and importance?

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Appendix A

2009 CMI Survey

10. Please rate each of the following in terms of how important you feel it is for effective mathematics instruction in the courses you teach. The list is not exhaustive. Space is provided for you to add more instructional activities and associated ratings.

	Not Important	Somewhat Important	Fairly Important	Very Important
Provide concrete experience/examples before introducing abstract concepts.	○	○	○	○
Take students' prior understanding of mathematics into account when planning and preparing for instruction.	○	○	○	○
Have students practice computational skills and algorithms.	○	○	○	○
Provide examples of explicit connections between mathematics and other disciplines.	○	○	○	○
Cooperative learning (groups of students work together but each is graded individually).	○	○	○	○
Collaborative learning (groups of students work together and all are assigned a single grade as a group).	○	○	○	○
Have students prepare projects, labs, and/or research reports.	○	○	○	○
Use graphing calculators to demonstrate ideas in class.	○	○	○	○
Have students use graphing calculators to complete assignments.	○	○	○	○
Have students use graphing calculators to complete exams.	○	○	○	○
Have students use computers.	○	○	○	○
Have students apply mathematics to solve problems in a variety of real-world and abstract contexts.	○	○	○	○
Use performance-based assessment (e.g., multiple-choice, T/F, matching, and other solution-only formats).	○	○	○	○
Use concept-based assessment (e.g., solve-and-explain-why, strategy justification, open-ended formats).	○	○	○	○

State and rate other activities (use the above rating scale)

2009 CMI Survey

11. This page has the same items as the last, but instead of rating their importance, please indicate how prepared you feel to do each of the listed items. Again, there is space provided to add more teaching activities and associated ratings.

	Not adequately prepared	Somewhat prepared	Fairly well prepared	Very well prepared
Provide concrete experience/examples before introducing abstract concepts.	○	○	○	○
Take students' prior understanding of mathematics into account when planning and preparing for instruction.	○	○	○	○
Have students practice computational skills and algorithms.	○	○	○	○
Provide examples of explicit connections between mathematics and other disciplines.	○	○	○	○
Cooperative learning (groups of students work together but each is graded individually).	○	○	○	○
Collaborative learning (groups of students work together and all are assigned a single grade as a group).	○	○	○	○
Have students prepare projects, labs, and/or research reports.	○	○	○	○
Use graphing calculators to demonstrate ideas in class.	○	○	○	○
Have students use graphing calculators to complete assignments.	○	○	○	○
Have students use graphing calculators to complete exams.	○	○	○	○
Have students use computers.	○	○	○	○
Have students apply mathematics to solve problems in a variety of real-world and abstract contexts.	○	○	○	○
Use performance-based assessment (e.g., multiple-choice, T/F, matching, and other solution-only formats).	○	○	○	○
Use concept-based assessment (e.g., solve-and-explain-why, strategy justification, open-ended formats).	○	○	○	○

State and rate other activities (use the above rating scale)