

Lifelong Learning: Mathematics Faculty Work to Improve Their Practice

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Abstract

The National Council of Teachers of Mathematics and the National Science Teachers Association advocate professional teaching standards that support learning environments that are contextual and meaningful for the learner, are student-centered, and involve the learner as an active participant in their education. The empirical data that support these recommendations are not only applicable to the K-12 environment but also to higher education and undergraduate studies. However, little empirical data have accumulated to guide the professional development for faculty members in higher education and how they might learn to teach to these Standards. This paper will provide an overview of the activities findings of a five year project funded by the National Science Foundation that provided support for the professional growth and development of mathematics faculty in higher education at five Mississippi institutions of higher learning.

Introduction

Universities and teachers' colleges nationally are concerned about elementary mathematics teacher preparation. These students in general are not exceptionally strong mathematically (Ball, 1990; Post, Cramer, Harel, Kieren, & Lesh, 1998; Silver, & Stein, 1996) and in most cases did not learn K-12 mathematics in a standards-based environment. But these future teachers will be expected to facilitate a reform-minded mathematics classroom. Therefore, it becomes the task of the preservice program to help future teachers shift their views about mathematics learning as well as extend and possibly correct their current understanding of the content.

I am attempting to partially answer the global questions: How can faculty in higher education better serve preservice teachers as learners in a Standards based learning environment? This National Science Foundation Early CAREER funded project explored this question by fostering a professional learning community that has helped mathematics faculty members: (1) be more attentive to their students' understanding of the content, (2) provide a more inquiry based learning environment for undergraduate students, and (3) better address the learning needs of their undergraduate students. The professional experiences and subsequent growth of the 18 mathematics faculty members participating in the Professional Mathematics Educators Forum (PME) are presented here.

The eighteen faculty members' educational backgrounds vary from master's degree level mathematicians and computer scientists to doctorates in mathematics education. These faculty members' classroom practice was not uniform across the group, varying from traditional lecture format to student-centered group investigation. Similarly their beliefs about teaching and learning, number of years in academia, and teaching experience in a K-12 environment varied widely. Their beliefs and classroom practices were monitored and used as a lens to examine their reactions and reflections on Standards based practice, the ways they analyzed and used K-8 video excerpts in their mathematics education courses, what they learned from watching their own classroom videos and excerpts from other PME members, and in what ways various interactions with their peers impacted their classroom activities and teaching. Despite their differences, they are all served the same student population, future K-8 teachers, and shared a common language. This paper will provide an overview of a five year professional learning community for mathematics educators at five institutions of higher learning in the state of Mississippi.

Background

The NCTM Standards and professional teaching standards support learning environments that are: contextual and meaningful for the learning, student-centered, and involve the learner as an active participant in their education. Yet similar to K-12 teachers (Cwikla, 2002), university faculty members' views of teaching and learning, range from teaching as transmission to student-centered construction (Samuelowicz & Bain, 1992). King (1992) reported that long-term retention and understanding for undergraduate students are most likely to develop from student-centered question-generating exercises in the collegiate classroom. And an interview study of university students also supported student-faculty interactions, concluding that for students' learning, meaningful classroom interactions with the professor ranked as one of the six most important classroom features (Clarke, 1995). However, in a study of university faculty and the stresses in their profession, "interactions with students" were found to be one of the facets of their profession that brought about the most angst (Gmelch, Wilke, & Lovrich, 1996). The stress of student interactions combined with varying faculty views of learning might contribute to dissonance between students and faculty priorities and goals for their relationship and interactions.

Developing a Rapport with Undergraduate Students

How can mathematics educators develop a better rapport with their students and better serve them as learners? Sherman and colleagues (Sherman, Armistead, Fowler, Barksdale, and Reif, 1987) described a four-step development process as faculty members improve their teaching. Faculty members begin by simply presenting information to their classes in the first stage. It is not until the fourth stage that the faculty member can facilitate a classroom that involves meaningful interactions between the students, the content, and themselves. Although I disagree that a rigid stage model accurately portrays faculty members' progression in their classroom teaching, as some faculty may never simply present material in a lecture format, these four different ways of interacting in the collegiate classroom can be used to describe and analyze practices.

Based on these above studies it is likely that there are many preservice teachers who are dissatisfied with their university courses and/or are not learning in a standards-based environment because (1) faculty might be stressed about their interactions with students and (2) not all faculty members provide meaningful classroom interactions with the students and the mathematics content. It has also been suggested that the majority of mathematics content courses offered at university taught by those with extensive backgrounds in mathematics, "reinforce rather than debunk the view of mathematics as a set of procedures to be memorized" (Battista, 1994, p. 468). As a result future teachers are not experiencing mathematics as sense making and problem solving, rather their K-12 socialization is perpetuated and they are exposed to more mathematics as rules and procedures.

If indeed there is this disconnect between faculty in higher education, their students, and standards-based teaching, how might mathematics professors develop and improve their practices? Gess-Newsome, Southerland, Johnston, and Woodbury (2003) investigated collegiate science professors' process of reform in an introductory science course to align with the National Science Education Standards. The three cases highlighted in their article detail the institutional, financial, and instructional supports that facilitated the faculty members' move to reform. They argue that reform must be driven by a faculty member's individual "pedagogical dissatisfaction" (p. 763). In other words an educator must possess a perceived need for change or sense disconnect between their beliefs about teaching and learning and their practice, before embarking on an improvement.

However, self awareness and reflection on one's practice might not be sufficient to encourage change and improvement. Teaching is not always the focus of a faculty member's career because typically teaching is not well rewarded and not heavily weighted in tenure and promotion decisions. As a result faculty members might not dedicate as much time to their teaching practice as to their research endeavors. In the area of mathematics and what are considered the other "hard sciences" Braxton (1995) found faculty members less likely to be receptive to teaching improvement initiatives. But in what type of environment(s) might mathematics faculty be receptive to professional development?

Mathematics Faculty and the K-12 National Reform

Mathematics educators might find themselves somewhat removed from their mathematics department colleagues, because of different student populations, courses, and issues in their teaching. In addition to interactions with students another source of high anxiety for faculty members is the development of their “professional identity” which is complicated by typically high self-expectations and finding their own niche in academia (Gmelch, Wilke, & Lovrich, 1996).

Paulsen and Feldman (1995) suggest that faculty will naturally develop as reflective practitioners through feedback from (1) students, (2) colleagues, and (3) consultants if embedded in a culture supportive of teaching improvements. In addition to feedback to guide improvement of their practice, it is argued that university faculty members must (1) define their teaching missions clearly, (2) articulate specific desired outcomes, (3) hold students to high expectations, (4) encourage student involvement in their learning, (5) provide comprehensive assessment of outcomes, and (6) develop climates more supportive of student learning and development. Kranier (2001) also stressed the importance of a community consisting of a “network of critical friends” (p. 289).

Monitoring the faculty members’ growth and development over the five year period was guided not by a stage model, but employed the horizontal and vertical dimensions described by Dall’Alba and Sandberg (2006). “The horizontal dimension relates to the skill progression that accompanies experience; the vertical dimension refers to variation in embodied understanding of practice” (p.406). The combination of both of these dimensions allows for multiple professional trajectories and accommodates for the context of the teaching and learning. In other words, a mathematics professor might be considered excellent in their Multivariate Calculus course, but struggle when teaching future teachers three-dimensional geometry. And in this case, when teaching preservice teachers mathematics, there are significant similarities across this student population nationwide. However, there are regional differences, especially since preservice teachers typically do not travel far from their childhood home to attend university. Therefore, in this study the mathematics faculty members are teaching a majority of Mississippi high school graduates how to teach Mississippi elementary students. This context likely differs from those preservice teachers enrolled in Mathematics for Elementary Teachers III at Dartmouth College. Understanding how mathematics faculty members improve their practices in both the vertical and horizontal dimensions is essential for improving teacher preparation.

These features of faculty development guided the development, structure, and assessment of the Professional Mathematics Educators’ Forum (PME). The mission of this community of university practitioners was to use data collected in their classrooms, both assessment and video, to learn from and critique each other for the purpose of improving mathematics teaching and learning.

Creating a Community of Practice

Many writings support collaboration and a culture of continual learning driven and designed by teachers (e.g. Clark, 2001; Darling-Hammond and Sykes, 1999, Shifter and Fosnot, 1993, Stigler and Hiebert, 1998). Communities of practice, and their connection to professional learning and eventual classroom impact require more detailed investigation. The words “community of practice,” have unfortunately been casually used to label many types of organizations. I will briefly review some of the work conducted in education and other fields on organizational learning and communities of practice to help more clearly define this term.

A *Community of Practice* can be used to characterize a professional group of learners with a common goal such as educating young people, a set of norms, expectations, and standards, and a method or manner to systematically share information about their practice (Wenger, 1998). Learning theorists have developed a view of learning that is socially constructed and embedded in the context of work and practice (e.g. Brown, Collins, & Duguid, 1989; Brown & Duguid, 1991; Grossman, Wineburg, & Woolworth, 2001; Lave, 1988; Lave & Wenger, 1991; Pea, 1990; Wenger, 1998).

Lave and Wenger (1991) describe their practice-based learning theory as “legitimate peripheral participation” in “communities of practice.” Accordingly, to separate the abstract knowledge and facts from the daily practice and work is not productive. Lave and Wenger’s work provide parallel notions of learning to those of Dall’Alba and Sandberg (2006) by incorporating both the professional skills as well as the daily context and environment. Similarly in Orr’s (1987, 1990, and 1996) study of service technicians, the corporation’s technical manuals and prescriptive sequence of steps for repair did not capture the complexity of the technicians’ practice and on the job reality of how ad hoc decisions are made. Through mentoring and story-telling the technicians were able to accomplish their tasks on the ground. The abstract knowledge in the technical manual oversimplified the procedures which is too often the case in education as well. New initiatives and educational reform should “provide support that corresponds to the real needs of the community rather than just provide abstract expectations.” (Brown & Duguid, 1991; p. 45).

To help bridge the gap between the “technical” manuals and the everyday practice, communities of practice can cultivate professional exchanges and conversations that are specific to the local context yet address the global necessities and standards of the profession and content. Grossman, Wineburg, and Woolworth (2001) describe a community of practice consisting of 22 English and social studies teachers in Seattle, Washington and the evolution of that community. They present a model of the formation of a professional community. The four dimensions of their model are: (1) Formation of a group identity and norms of interaction, (2) Navigating fault lines, (3) Negotiating the essential tension, and (4) Communal responsibility for individual growth. Each of these dimensions is also described in three stages: beginning, evolving, and mature. Their model provides a clear schemata for and markers for the evolution and development of a community of practice. As documented in their work and others (Little, 2002;

2003) there are many obstacles and barriers to fruitful communication and exchange that will improve professionals' practices in the classroom.

Developing a community of practice is a process which requires a long term vision, a shared mission and desire to improve, and commitment by the participants to the goal of questioning the status quo and finding ways to improve for the sake of students' learning. The PME Community of Practice developed via email communication, in-person meetings, through the sharing of classroom materials, and by carefully developing a level comfort and safety among the participants, vis-à-vis our common goal of educating future teachers.

Professional Mathematics Educators' Forum Overview

Mississippi University (pseudonym) is a four year institution with a student enrollment of about 14,000 undergraduate students. A large portion of the student body transfers from community colleges in the surrounding area and even more so in teacher education with a majority of non-traditional students. As a result over 70% of the future teachers who graduate from Mississippi University have had at least two semesters of mathematics content courses at these four other institutions which will be called the 4CCs in this paper for purposes of brevity. The 18 faculty members participating in the PME are employed and teach at Mississippi University and the 4CCs.

Prior to this project, mathematics faculty from the five institutions met periodically to discuss course alignment and articulation but not as a whole group and not systematically with clearly defined goals. The PME provided the first opportunity for these mathematics and mathematics education faculty members to focus on the teacher education courses, exchange best practices, discuss course activities and specifics, share classroom video data, and simultaneously read books and journals articles to improve their teaching.

Faculty Survey

Before the first PME meeting during the summer of 2003 and again at the end of the funding period in the fall of 2008, each faculty member completed a written survey. This instrument addressed (1) their teaching experience and educational background, (2) their views of learning and teaching, and (3) asked them to select from a list of adjectives that describe the preservice teachers they serve. The views of learning and teaching portion of the survey consisted of 18 items that were constructed to place faculty members' views on a continuum between: (1) learning opportunities are most effective when they are student centered and (2) learning opportunities are best if they are curriculum centered. A factor analysis of the 18 items was conducted and a detailed analysis can be found in Cwikla (2002). Two item examples follow. (1) Learners benefit more if they solve a problem than own than if they follow someone else's method. (2) It is better to plan learning opportunities that will build on what I think students already understand than just letting things happen spontaneously. For each item the respondent scores a one through four for disagree or agree. Faculty could score 18-72 points and

the higher the score the more student-centered their views. The faculty members' view of teaching and learning were used to investigate their classroom practice and to better understand the connection between self-reported data and actual practice similar to the work of Gess-Newsome et al. (2003) study of science faculty mentioned above. The pre and post data and changes in their belief system were also evaluated at the end of the study.

Meetings, Activities, and Video Recording

The PME faculty participants met during June 2003 for their first formal meeting focused on the courses offered and learning goals for the students. During this meeting faculty discussed the mathematics content within and across the four courses required by the program at Mississippi University and compiled a formal list of detailed content for each course. More specifically faculty in small groups based on the courses taught also discussed specific topics and the accompanying activities they have found effective. In addition each of the institutional missions and specific program goals were discussed. And as a whole group we formalized the areas we would like to improve as mathematics educators and members of the PME (See Figure 1). This began our professional relationship and the dialog continued via our listserv.

Subsequent meetings focused more specifically on classroom practices and individual activities. In February of 2005, the day long meeting allowed PME members to explore a variety of manipulatives and technologies. They were provided with a large assortment of elementary manipulatives such as Pattern Blocks, Cuisinaire rods, and dozens of others to investigate and then place orders for their classroom. The remainder of the day long meeting consisted of individual presentations by each faculty member. They modeled classroom tasks, activities, and projects they had found effective for their peers.

FIGURE 1 - AREAS WE WOULD LIKE TO IMPROVE AS MATHEMATICS EDUCATORS.

1. Provide connections and relevance for the preservice teachers to their future classroom
2. Help students better understand mathematical connections
3. Provide more consistency among topics
4. Use more problem solving
5. Provide more applications and modeling of applications
6. Diagnose and meet the needs of this student population more effectively
7. Develop more as a facilitator of learning
8. Integrate more technology in the classroom and learning activities
9. Help students move from mathematical anxiety to a comfort level
10. Conduct action research in our own classrooms

Later meetings involved visits to other campuses and individual classrooms so faculty members could demonstrate their uses of technology such as the geometer sketch pad or the use of a digital presenter or graphing calculator. Overtime the faculty members become more and more comfortable sharing their classroom activities and literally opening up their classroom doors.

Other PME meetings were more data driven. The faculty members all administered assessments and surveys to their preservice teachers. The assessments consisted of released TIMSS-R questions and teaching and learning belief items. They compared these data to their students' performance overall in their courses as well as across faculty members and across the five campuses represented in the PME. The faculty members identified recurring areas of weakness and content that would require more focus and attention.

In addition to the written and quantitative measures, each faculty member agreed to have their classroom video recorded. They were given a copy of the video to watch and complete a guided written reflection. Excerpts from each class were identified by two researchers and then shared with the entire group during a meeting. The group watched the video excerpts together and provided each faculty member with non-anonymous feedback on their videoed lesson. It is important to note that the terminology used during the meeting with the faculty members, was not one of evaluation, instead terms such as "feedback," "guidance," "suggestions," and "help" were used to soften and indicate clearly the purpose of the activity. In addition the questions on the feedback sheet were carefully designed to encourage positive feedback as well as suggestions for improvement. This proved to be an effective professional learning opportunity and one that for some members was an "unfolding circularity" (Dall'Alba & Sandberg, 2006) and the written results are currently under review.

In addition to the professional learning opportunities provided the PME members, each of the classroom videos were qualitatively coded to better understand individual lessons and faculty member's practices. The coding scheme used for analysis was based on that designed by Gearhart, Saxe, Seltzer, Schlackman, Ching, Nasir, Fall, Bennett, Rhine, and Sloan (1999). Their "Integrated Assessment" and "Conceptual Issues" codes were used to code each video by two independent coders. Integrated Assessment captures students' opportunities to participate in classroom discussions built upon students' mathematical thinking" and "Conceptual Issues captures students' opportunities to engage with conceptual issues underlying problem solving" (p. 297). These results and the pre-post analysis are currently underway.

Discussion

The mathematics faculty members in this project were in general willing and enthused about their participation in the PME and the idea of sharing best practices with one another. Some of the faculty members were apprehensive about the prospect of being video recorded in their classroom, but in the end were comfortable with the overall professional experience and the growth that resulted from sharing video clips with their peers. The supportive climate of the

PME and the culture of improvement and development have helped all the participants improve their practices as has been seen in preliminary pre-post video analyses as well as in their closing written reflections. One PME member shared, “Not only have I been able to demonstrate what I consider effective lessons, but I have seen my colleagues in action demonstrating their best practices.” Another remembered that when she was asked by her department chair to participate in this group, “little did I envision this as a beginning to rethinking the methods with which, at the time, were used to deliver the required content of each mathematics area.” And another faculty member who made significant shifts in both her views of teaching and learning as well as her practices, shared the following.

Perhaps one of the most important things I have learned through my participation in PME is to be flexible and open to change in the class. My students are of a different generation than me and their outlook is very different from mine. Sometimes it is best just to listen and then make some positive remark.

These and other reflections seem to indicate faculty members’ willingness to focus more on their students’ thinking and the methods they employ.

Some overarching conclusions from the five years of work indicate that (1) classroom video is an effective medium for professional discussion and comparison for faculty members in higher education. (2) Mathematics faculty members in higher education are a diverse group of professionals in their views of teaching and learning, and their practice, just as any group of K-12 educators would be. This is displayed through their reflection on their own classroom practice as well as their evaluation and suggestions for their peers who might have similar or different classroom environments. (3) Just as with K-12 teachers who use traditional methods of teaching mathematics, faculty members in higher education need to be exposed and educated about other methods of teaching and learning and in particular those aligned with and suggested by the NCTM Standards and reform movement. This might be partially accomplished through watching and analyzing videos of peers’ classrooms and possibly through partnering and sharing with educators with alternative teaching methods. And lastly (4) in this study the faculty members’ views of teaching and learning, their actual classroom practice, and their reactions and comments about peers’ classrooms were highly aligned. This suggests the views and values held by these mathematics faculty members are steady and have significant impact on their interpretation of what is effective mathematics teaching in higher education.

In conjunction with the forthcoming results of this longitudinal study, it is important that as a field we consider not only the mathematics courses offered for teachers later in their preparation such as methods courses and the practicum and field experiences, but also their entire mathematics collegiate experience. The first collegiate experience of future teachers is typically college algebra. How this and other content courses impact their vision of mathematics teaching and learning as well as how these courses can be improved through professional development for faculty in higher education deserve more attention. When students come to a methods class surprised that they have “never thought about math in this way” our attention needs to be focused on the mathematics content courses that might not be helping them to think about mathematics as problem solving and sense making.

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