

MOTIVATING PROSPECTIVE ELEMENTARY TEACHERS TO LEARN MATHEMATICS VIA AUTHENTIC TASKS

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Motivating prospective elementary school teachers (PTs) to learn mathematics in university mathematics content courses remains a constant challenge. While authentic tasks are readily available for students taking methods courses, which generally appear later in students' educational experience, authentic experiences for students enrolled in mathematics content courses are more challenging. We examined the use of a particular kind of authentic task for PTs enrolled in mathematics content course, creating and enacting a mathematics activity with children, and found that PTs were excited about this activity and, knowing they would need to apply the knowledge learned in the course, felt additional motivation to learn the content and engage in the university classroom activities.

RATIONALE AND BACKGROUND

Elementary school children in the United States are not developing acceptable levels of mathematical proficiency (National Center for Education Statistics, 1999). For teachers to teach so that their students develop mathematical proficiency (Kilpatrick, Swafford, & Findell, 2001), teachers must develop deep and flexible understanding of the mathematics they are teaching (Ball, 1990; Ma, 1999; Sowder, Philipp, Armstrong, & Schappelle, 1998). For prospective elementary school teachers (PTs), most colleges and universities in the United States offer specially designed mathematics courses focused on rich mathematical content knowledge, but although such courses have been offered by many universities for decades, teachers' mathematical content knowledge continues to be a major area of concern (Tatto et al., 2012).

Although most PTs and teachers can execute algorithms, many struggle when asked to explain them conceptually (Ball, 1988/1989; Ma, 1999; Thanheiser, 2009) and may be unaware that rationales for the algorithms exist. With recent calls for a focus on having students in the United States develop conceptual understanding (Common Core State Standards, 2010; Kilpatrick et al., 2001; National Council of Teachers of Mathematics, 2000), the fact that most PTs and teachers do not understand the rationales behind the procedures they teach is a major concern for those of us responsible for teaching PTs. However, PTs do not share this concern because many of them hold the beliefs that

1. Knowing how to apply procedures is synonymous with understanding (Graeber, 1999).
2. "If I, a college student, do not know something, then children would not be expected to know it, and if I do know something, I certainly don't need to learn it again" (Philipp et al., 2007, p. 439).

Thus many PTs view their mathematics content courses as annoying prerequisites they must endure instead of as opportunities to develop richer mathematical understanding. Of note is that in the United States, PTs taking content courses are typically years removed from teaching, working with children, or even their methods courses, thus they often struggle to see the connection between the university content course and their future careers.

Our interest is in trying to understand and explore ways to motivate PTs to learn the mathematics of their content courses. In prior work (Thanheiser, Philipp, Fasteen, Strand, & Mills, 2013) we have shown that a brief one-on-one content interview with PTs led to the PTs changing their beliefs about mathematics and about their understanding of mathematics, leading to the recognition that (a) there is something to learn beyond procedures, (b) their own knowledge is limited and they need to know more to be able to teach, and (c) engaging in the mathematical activities in their content courses will lead them to learning important content.

In this study we explore a new approach designed to sustain PT motivation and engagement in learning mathematics throughout the course, namely, creating and enacting a family math night (FMN) activity. Such an activity is typically found in methods courses, but we purposefully incorporate it into a content course with the goal to motivate PTs to learn mathematics. The central focus of the activity remains on the mathematics throughout the course.

THEORETICAL FRAMEWORK

Although most researchers studying learning examine the cognitive skills required to solve a task, other factors, such as motivation and engagement (Dweck, 1986; Middleton & Jansen, 2011) and authentic tasks (Newman, King, & Carmichael, 2007) play a major role in learning.

Motivation and Engagement

A student who is not motivated to learn will not engage in a task and thus will miss the chance to learn, whereas students who are motivated to learn and engage in tasks are more likely to learn. We adopt the definition of Hulleman, Durik, Schweigert and Harackiewicz (2008) of motivation as “a motive (e.g., wish, intention, drive) to engage in a specific activity” (p. 298). This is consistent with the theory that engagement in learning activities in the classroom can be seen as the “outward manifestation of a motivated student,” (Skinner, Kindermann, & Furrer, 2009, p. 494) a “visible manifestation” (Skinner & Pitzer, 2012, p. 22), or “the action component of ... motivation” (p. 24). Engagement describes the interaction of a student with a task and is easily observable. Engagement, and thus motivation, is an essential element of academic learning as it is “a robust predictor of students’ learning, grades, achievement test scores” (Skinner & Pitzer, 2012, p. 21).

Authentic tasks

Academic tasks have been identified as “especially important determinants of motivation and engagement” (Skinner & Pitzer, 2012, p. 28). To promote engagement, teachers should provide students with tasks that are “authentic, challenging, relevant to students’ experiences and concerns, hands-on, project-based, integrated across subject areas, and that allow students some freedom to choose their own direction and to work closely in cooperative groups over long periods of time” (Skinner & Pitzer, 2012, p. 33). One way of making a task more authentic is by connecting the university classroom to the real world (in the case of PTs the K-12 classroom) (Newman et al., 2007). Research has demonstrated the importance of authentic tasks, as “students who experienced higher levels of authentic instruction and assessment showed higher achievement than students who experienced lower levels of authentic instruction” (Newman et al., 2007, p. vii).

PT learning

To help PTs develop mathematical understanding, mathematics teacher educators need to understand three things: (a) the conceptions PTs bring to teacher education because “the key to turning even poorly prepared prospective elementary school teachers into mathematical thinkers is to work from what they do know” (Conference Board of the Mathematical Sciences, 2001, p. 17); (b) how those conceptions can be further developed, by, for example, using a hypothetical learning trajectory (Simon, 1995); and (c) how to motivate PTs to learn mathematics. This paper focuses on the latter point. Prior work has shown that classroom environment can influence learning goals and motivation (Morrone, Harkness, D'Ambrosio, & Caulfield, 2004). We share our results of incorporating a FMN activity into a content course for teachers to motivate them to learn the mathematical content of the class.

METHODS

The FMN consisted of pairs of PTs finding/modifying/developing a mathematical activity to work through with elementary school students. In Week 5 (of a 10 week course), students were asked to pair off and sign up for a topic (one of the topics covered in this course) and then: (a) find what children are expected to know at various grade levels about this topic via the Common Core State Standards (2010), (b) decide on a mathematical goal for their activity, (c) use online resources such as www.nctm.org to find ideas for their topic (including browsing the publication *Teaching Children Mathematics* and navigating through the resources provided, including www.illuminations.org), (d) (re)visit their topic in the textbook used in our course, and finally (e) use the internet and other sources to find additional ideas, if needed. In Week 6 students were asked to send a one-page idea of their activity to the instructor. In Week 7, the pairs of PTs met with their instructor to discuss their ideas and receive feedback. These meetings focussed on clarifying the mathematical goal of the activity and linking the activity to the goal. Once the PTs received feedback on their ideas, they created a draft of their activity, which was then presented in the

university classroom to their peers. This allowed the PTs to experience many of the activities and give/receive feedback from their peers and their instructor. The PTs then had a final chance to revise their activity and present it at the FMN event at a local elementary school (at the end of Week 8). The goal of the activity was to allow the PTs to explore one mathematical topic in depth in an authentic setting and motivate them to learn the mathematics of the course.

The authors analysed data from work with 23 PTs in a 10-week (4 hours a week) content course focusing on number and operation at a large state university in the northwestern United States. All students participated in the creation and enactment of a FMN activity and completing three surveys on this experience throughout the term. The surveys were administered before the FMN, immediately after the FMN, and at the end of the term. The surveys were designed to allow the PTs to reflect on and share their experiences (see Table 1 for sample survey items).

Sample Survey Questions for reflections of the FMN activity

- (a) How do you think the FMN activity contributes to your learning in this class? (S1)
 - (b) How do you think that creating and enacting a family math night activity this term affected your learning in this class? Please explain. (S3)
 - (c) Did anything surprise you? I expect that many things surprised you. I would love to hear at least two things that were surprising to you. (S2)
 - (d) What did you learn? (S2)
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Table 1: Sample Survey Questions (S1=Survey 1, etc.)

Because little is known about PTs' reactions to the creation and enactment of a FMN experience, we used a grounded theoretical approach (Strauss & Corbin, 1990) with open coding (Strauss & Corbin, 1998) to analyse the written responses to the surveys. We read through all PT responses and identified themes while we read the responses. For example after reading Hannah's (all names are pseudonyms), statement "I'm excited about planning and enacting a FMN activity! It will be fun to put what we've learned into practice and spend some time with actual students," we created a category labelled "Excitement/Fun" and when we came across similar statements we placed them into that category and/or adjusted the category as needed (i.e. this category was initially established for survey 1 but reappeared on survey 3, thus the future and past tense were taken out to encompass both. Another instantiation of this category was Alex stating, "It was some of the most fun I've ever had with kids.")

RESULTS AND DISCUSSION

PTs entering the content courses often think their knowledge of mathematics is sufficient to teach K-3 and thus see this class as an inconvenient prerequisite rather than a class in which they can learn something useful. Sixteen of the 23 PTs in this study stated at the beginning of the course that they knew enough math to teach K-3, 2 were ambivalent, and 5 said they did not know enough math to teach K-3. However,

these 5 did not refer to their lack of content knowledge, but rather to their lack of knowledge about teaching. For example, one stated, “While I think I can do all of the math in a K-3 class, I'm not sure I have the tools to teach those classes.” So in general the PTs feel confident that their content knowledge suffices to teach K-3 and may not see any relevance to the course. The FMN activity made the learning in the university classroom immediately relevant to the PTs and thus has the potential to change the PTs’ perception of the usefulness of the course. PTs were very excited about the authenticity of the task, focusing in particular on the fact that rather than simply planning the task, they were actually enacting it. Twenty of the 23 PTs mentioned this in their reflections. For example, Jennifer stated:

Family Math Night is hands-on. Everything that we have learned about explanations and justification and talking about math are all things I can apply to this night. Reading about it and talking about it is only doing so much for my brain. Actually putting it to real practice with real children ... is going to be extremely beneficial to my learning experience. Getting to watch it all play out will help me more.

The PTs were typically nervous but excited in creating and enacting a FMN activity. This excitement motivated them to engage with their tasks and further developed their mathematical understanding. Seventeen of the 23 PTs stated that they held a deeper understanding of the mathematics of their activity through FMN. One PT, Heather, reflected on how her knowledge changed throughout the activity:

I learned the difference between sharing division and measuring division. It was hard for me to come up with word problems at first for both kinds of division but by the end of preparing the lesson I can do it.

Almost all (21 of 23) of the PTs reported after the FMN that their activity went well and most (16 of the 23) explicitly stated that it was a lot of fun. Alex, for example, stated

It was some of the most fun I've ever had with kids. ... actually seeing all the different ways children solved the problems was really fascinating. It was also interesting to see all the different levels of the children; we weren't expecting such young children, we had some first graders and a kindergartner, but they were able to solve a good portion of the problems.

The FMN activity provided this PT with an *authentic task*, enabling her to engage more deeply in the mathematical activities of the class. In addition, the FMN allowed PTs to realize other important aspects of mathematics teaching. For example, 18 of the 23 PTs commented on the fact that children come in and learn at different levels, which motivated the PTs to dig deeper into the mathematics and create multiple entry levels for students. Sixteen of the 23 PTs seemed genuinely surprised by the fact that children are interested in mathematics. PTs often are scared of mathematics and project their fear onto the children with whom they are working. Experiencing mathematics as fun for all is an essential element of teacher education. When asked whether the PTs would recommend future PTs to take a math class with family math night, all PTs recommended such a class, with 17 stating “definitely take it with the FMN” and 6

stating “take it with the FMN.” They argued that “it truly is a practice of what we will be doing each day with students” and “my learning in this class was very focused and determined because I knew that I would need to know the subject well enough to teach it, and that is a whole different level of understanding for me.” In later reflections, some PTs explained that it was the immediate applicability of their learning that motivated them to really pay attention in the class. This applicability is especially crucial for content courses, which are typically years removed from PTs working with children.

SUMMARY

In summary, we know that (a) the PTs experienced the FMN as an authentic activity, (b) the FMN activity was a highly motivating activity (the PTs had fun and realized that the children had fun too), (c) the PTs stated that they learned various things through the FMN activity (such as how children do/learn mathematics), and (d) the PTs learned mathematics through the FMN activity. However, we do not want to overstate our claims. We as yet have no data as to the effect the FMN activity might have on PTs’ experiences in courses other than this content course. We are also not sure of the extent of the mathematics learning that happened as a result of the FMN activity. We believe that the PTs learned the mathematics of their activity at a deeper level (see Heather’s comment about division above). We also believe that, at least for some PTs, the FMN activity affected their learning throughout the course (see Hannah’s comment). Some questions that remain for further research: 1. Does the FMN activity change the PTs’ stance towards learning mathematics in general (beyond the context of their task)? 2. At what level does the FMN activity affect the PTs’ mathematics learning (local to the task, global to the course, global to the sequence of courses, global to mathematics)?

CONCLUSIONS

Learning mathematics in content courses designed for PTs is complicated. We (mathematics educators) are still working on understanding how to motivate the PTs to learn in our courses. Approaches such as working with children in an early field experience (Philipp et al., 2007), a one-on-one content interview (Thanheiser et al., 2013), and the FMN experience described in this paper have been shown to motivate PTs to learn mathematics content. (We want to note that the emphasis of these experiences is not on the “methods” aspect, i.e. *how do I create a lesson?* but rather on the “mathematics” of the activity, i.e. *What mathematics content do I want to work on with the children? What is my mathematical goal?*, etc.) Given the importance of mathematical content knowledge for teaching and the extensive research highlighting the lack of rich teacher content knowledge, the FMN experience described, which may traditionally not have been considered for inclusion in content courses taught in mathematics departments, may be precisely what we need to motivate our students to learn.

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