Promoting Engagement and Supporting Leadership Development: Online Teacher Professional Development at the Math Forum

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Abstract: Teacher professional development (TPD) in its current state is typically episodic, fragmented, and often not rewarding over the long haul. There is need for a more substantial and extensive core set of TPD experiences that focus on accountable, constructive engagement with both student learning and critical peer communities. The Math Forum @ Drexel University has created an online format for providing sustained TPD experiences and identifying potential teacher leaders in mathematics for leading future online communities in ongoing TPD.

Professional Development Issues

There has been considerable critique in the research on teacher professional development (TPD) suggesting that short term TPD is often not well aligned with the needs of teachers and does not deliver information in a way that teachers can find useful (Desimone, Porter, Garet, Suk Yoon, & Birman, 2002; Schlager & Fusco, 2004). Further, there has also been discussion about whether online TPD can: (1) contribute to better meeting the needs that teachers have in their classrooms, and (2) meet those needs, while at the same time, efficiently meld with teachers' already busy schedules (Casey & Rakes, 2002; Grant, 1996; Means, Blando, Olson, Middleton, Morocco, Remz, et al., 1993). This presentation reports on the ongoing research connected with the Math Forum's NSDL workshop project, *Leadership Development for Technology Integration: Developing an Effective NSDL Teacher Workshop Model* (LDTI), that was designed to provide more aligned TPD through a combination of online and face-to-face workshops.

Drawing on our preliminary data analysis of participant interviews and analysis of the online interactions from the professional development sessions, we seek to identify the opportunities teachers have to engage in mathematical thinking and discourse that can contribute to their improved teaching (Darling-Hammond, 1998; 2000). Further, we discuss the potential of these workshops to identify teacher leaders and the way those leaders might contribute to future online communities of practice to further the development of other teachers' mathematical discourse and thinking.

The Math Forum LDTI-TPD workshops are unmoderated workshops and so there are further challenges to creating opportunities for teachers to learn. We will discuss some of the ways we are beginning to identify moments of opportunity in this workshop format and our efforts to think about how to make those moments more fruitful.

Math Forum Online Resources and Workshops

One of the problems that exist with TPD is the gap between the content of the professional development experience and the classroom. Teachers are not given the opportunity to apply what they learn in a one-shot TPD course and get any feedback, and this assumes that they are able to take applicable content back to the classroom. The Math Forum attempts to close this gap by providing online experiences where participating teachers can work together over time, to identify issues, solve problems, and engage in discussions that bridge TPD and their classrooms.

The Math Forum's TPD provides a venue for teachers to continue to learn relevant mathematics as they focus on issues of learning and teaching. In some workshops, teachers are provided with opportunities to engage with "school mathematics" tasks and participate in extended analysis and discussion of the problems, their activity with it, and challenges, issues and opportunities the task might present for their students. Part of this extended analysis includes making their solutions public so the class has an opportunity to question and reflect on individual and collective solutions. Since the Math Forum has collected students' Problem of the Week (PoW) submissions for many years, teachers also have the chance to analyze student work of the same problems they solve and begin to develop a robust understanding of both the variety of ways individuals can engage with the task and the potential affordances and constraints of each approach. Students submit solutions to PoWs and they are given to mentors who often have a dialogue with these students in the PoW service. Teachers can then later both work through the math problems themselves and later look at this archive of student solution and student discussions with mentors. By connecting TPD directly to problem solving through the PoW, both their own and student problem solving, there is an increase in teacher interest, as well as providing insight into student thinking.

The Math Forum also provides a suite of other online workshops and TPD activities that serve to bridge the Math Forum resources and classroom practice. We have developed specific workshops that focus on supporting teachers in implementing the PoWs and using the resources that accompany them, including teacher resource pages with implementation suggestions, and the Problem Solving and Communication Activity Series; an ongoing series of resources designed to help teachers integrate the PoWs and problem solving strategies in their classroom.

Engaging Teachers in Mathematical Discourse

Teacher quality is widely recognized as a significant issue in the teaching and learning of mathematics (Ball & Cohen, 1999; Goldsmith & Schifter, 1997; Hill, Rowan, & Ball, 2005; RAND Mathematics Study Panel, 2003; Shulman, 2000). Issues relating to teacher quality intensified following the reform mathematics movement and the publication of the National Council of Teachers of Mathematics' (NCTM) *Principles and Standards for School Mathematics* (2000), which asked teachers to focus on students and student thinking in the planning, teaching, and assessing of mathematics. In this research, a strong emphasis is placed on the importance of classroom discourse and legitimate mathematical inquiry. These instructional practices require more flexibility, creativity, and a deeper understanding of mathematics than was required for previous conceptualizations of teaching mathematics.

The Math Forum employs the Blackboard environment to provide online TPD experiences to teachers. At the core of these experiences is the focus on facilitating interaction between participants. When teachers enroll in TPD through the Math Forum, they are involved in six-week courses that require them to engage in discourse with fellow classmates through problem solving and analysis of student solutions. Once teachers solve a given task individually, those responses are made public for all participants to read. Teachers then move to the online discussion tool embedded in Blackboard to provide feedback about the class's solutions and engage each other through ongoing discussions related to the tasks and their solutions. After this exchange, teachers are presented with student solutions from the Math Forum's vast library of submitted PoW solutions from the past decade. Teachers again are asked to engage in discourse, this time using the student solutions as the basis for their conversations. Throughout this process, teachers are formally engaged with each other in discourse related to the mathematics of the tasks, their own solutions, which can include misconceptions and incorrect responses, as well as the student solutions. The conversations around problem solving are a critical part of the production of meaning and one of the most obvious ways that the Math Forum develops functioning communities of practice.

One example of the type of problem teachers face is the *Runners* problem. In the first stage of this problem teachers are given a graph of two lines that represent the "position" of two runners over a specified time interval (see Figure 1). The teachers are initially asked to analyze the graphs and make note of what they notice, as well as what their students might notice about the graphs. The intent of this open task is to focus the teachers' attention on the importance of interpretation, context, and reasoning in mathematics. Teachers are ultimately challenged to create their own "story," or context for the problem, to discuss the impact of that interpretation on the "solution" and to collaboratively explore the mathematical ideas that emerge under each interpretation. The graph is a boundary object around which the teachers can define themselves as a working group and explore their own ideas (Sfard, 2007; Stahl, 2008).

While this research is in its early phases and ongoing, we present a couple of examples of the types of data we are beginning to see working with these kinds of objects in the online TPD workshop. Below is a post from a discussion called *Analyze Graphs*. In this discussion the teachers were specifically instructed to make some sense out of the graph they were given (see Figure 1). Here we see Denise [pseudonyms used] responding to a colleague's comment about their interpretation of the race:

> Denise: I didn't see this as an uphill and downhill race, but just two runners starting at different places. Becky's comments caused me to look back at the y-axis label. I think *Position* could mean starting at 100 feet or starting at 0 feet on a level or a hilly surface. I interpreted this as two runners, running the same distance, starting at two different places, crossing at a point in race and finishing in a different amount of time due to different speeds. With that interpretation, I had the question, would this be a race? If so, why are the runners beginning at different places? If not, what are the runners doing?

Denise describes a very nice potential interpretation of what the graph represents. A number of teachers' comments implied an understanding that, because the lines in the graph go up and down, the runners are either going "uphill" or "downhill." They mistook the graph for an index of the physical world and then attempted to interpret that index, which in this case is similar to the "graph as picture" misconception that is common in both elementary and high school students (Kaput, 1987). But Denise has a different semiotic interpretation. Rather than seeing the graph as a direct index of some physical feature in the world she sees the graph as a more symbolic representation of situation: that runners could begin at a different point 100 feet apart. In this way she is able to come up with a more interesting interpretation of the graph, but more importantly, a more accurate understanding of what this graph could represent. Additionally, she focuses on the physical interpretation of the situation, wondering, "what the runners are doing" in order to further pursue the implications of her interpretation.

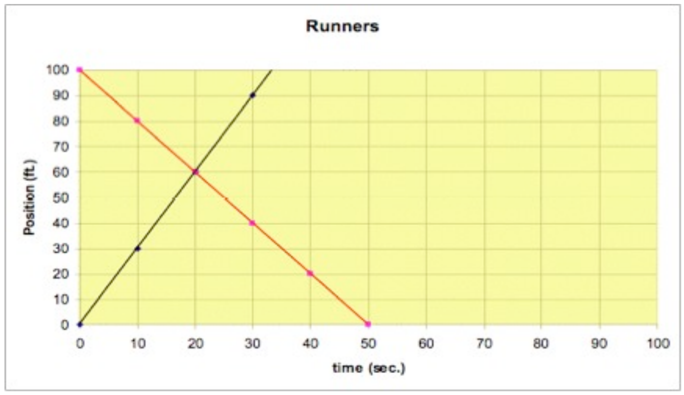

Figure 1. Runners graph used in the Math Forum's TDP experience [created using online applet (NCTM, 1998)].

One of the powerful outcomes this type of Math Forum problem generates is that it sets up a potential organic learning situation. Denise's post is evidence of her reflection on the scenario and emerging realization that the graph could represent many different physical events. In short, there is evidence that she is beginning to see that the graph is a collection of points and each point is a snapshot of the values of two quantities (in this case, time and position). Further she enlists the support of her colleagues, enacting an *in the moment* community of sorts to collaboratively address some of her observations and question or affirm them.

Denise's original post did, in fact, result in a short interaction. In the following consecutive posts we see some further discussion of Denise's ideas, as well as a possible "missed opportunity" for deeper discussion:

Belinda: Your question is very interesting. I agree, that my advanced thinkers might think of that as well. How can it be a race with different starts and different paths? For example, if the students run track or something all racers are at the same start.

Natalie: I originally thought of this like a relay race where one runner starts from a cone on one side of the field while the other starts at the other end of the field and the runners where switching places, if they only had 50 sec to run the race who ever was closest to their finishing point wins. I have seen the PE teachers do this with their classes, but I don't think a real world race would be set up this way.

Neil: I agree with how you see it. I thought it might be a relay race too. I was thinking of swimming starting on different ends of the pool.

Each of the respondents takes up some of Denise's questions about what is going on here and then speculate about it. Therefore, Denise's post was an initial catalyst for additional conversation, although simple in this case. Belinda and Natalie specifically take up the scenario posed by Denise (the race starting at different locations), but they do not take the discussion very far. Belinda suggests that some of her students might come up with a similar interpretation of the graph, but she leaves the issue there. Neil agrees with how Denise perceives the graph, but does nothing more than agree; he does not take up the issue or develop it any more either.

In general the teachers do not pick up on the mathematical insight of Denise–particularly the notion that the graphs are representations of quantities and not the events themselves and that attempting to understand what the graph represents is a first step in mathematical problem solving (Pólya, 1945). Denise herself does not come back to the conversation and ask people to develop their mathematical ideas any further. In our unmoderated TPD, we continue to find many "moments of possibility" with limited follow-up conversation, but then the discourse typically stalls out. While we had anticipated this to occur, we had also anticipated that we could mediate it via the refinement of the instructional tasks posed and instructional scaffolding (i.e., effective prompts, etc.). While one line of our work falls under this broad design-research umbrella, we are also interested in the ways in which participants can impact the focus of the conversations and the issues taken up by their fellow participants.

Identifying Potential Teacher Leaders

Prior research at the Math Forum has identified three types of teachers involved with online TPD experiences (Renninger & Shumar, 2002). The three groups are based on teachers' aptitude for technology and mathematics, and range from weak to strong. Type 1 teachers are highly interested in the TPD and ready to interact with others around mathematics. Type 2 teachers seem interested, and ready to interact, but may have some hesitation to fully participate. Type 3 teachers are less interested in participating and provide very limited feedback to the group, and in most cases, seek little feedback. The Type 1 individuals who do stand out in online workshops make similar references to the TPD: (a) they like the amount of math and the rich conversations that emerge, (b) they enjoy integrating the PoWs, and (c) they identify good ideas that are practical for taking into their own classes.

Based on the teacher types research, the Math Forum's process for identifying mathematics leaders has been modified from its original ideas. In the past, weeklong face-to-face workshops with teachers were used to identify potential teacher leaders. Follow-up face-to-face workshops were then held to work with the identified group, who became moderators in future online Math Forum workshops. In our recent work, we have begun to conceptualize ways in which online activity could serve to identify and incubate online leaders and workshop facilitators. As potential leaders began to shine in the online courses, they were contacted with an opportunity to join other potential leaders in a face-to-face workshop sponsored by the Math Forum. Leaders from all over North America have been brought together on several occasions to participate in a face-to-face workshop. The primary purpose of these workshops is to have the participants join Math Forum staff in designing materials to be used in current and future courses, in which many of the new leaders become facilitators.

If we look at a separate interaction between Denise and another teacher, Isabel, we see Denise's potential as a leader in an unmoderated online workshop environment:

> Isabel: My conclusion goes more toward the need of our students in regards with this graph. If we can have so many interpretations, we can imagine them very confused about the meaning of the graph. Then, we, as teachers should not use a graph like this without a verbal description of the situation. Every graph we teach need to include the scenario described by the graph. That way the students will learn better how to read the graph correctly.

> Denise: I'd have to say that I disagree with you. I think that one of the most valuable lessons that students should always come back to is that the mathematics of many representations (graphs, equations, etc.) are tied to a piece of a real life situation. It brings meaning and understanding for the students themselves to determine which piece of the representation ties to which part of the situation. Hearing other students' ideas - both right and incorrect - will help them to solidify their understanding. If we always give them the situation, they may not develop this critical skill and then math becomes detached from "the real world."

In the excerpts above, we see Isabel and Denise functioning in a pseudo-leadership capacity and affecting the direction of the conversation. In particular, we see Denise making the explicit connection between her students and the mathematical ideas at play. We have found working at this intersection effective in supporting sustained math teacher engagement in an online setting (Clay & Silverman, 2008). With regards to leadership identification, it has become apparent that the leadership potential of online participants was more accurately gauged through their online interactions such as these and we continue to develop ways to tap that potential.

Concluding Remarks

The Math Forum has established a record of successfully providing online resources to push teachers' thinking about their own mathematics content knowledge, mathematics teaching, problem solving, analyzing student work, and becoming a member of a larger community of practice. In the process, teachers have been identified as leaders based on their levels of interaction and enthusiasm in the PD they are enrolled in. Because of this, teachers have remained involved in ongoing PD by working with other teachers as facilitators and participants in other Math Forum PD opportunities, some of which they helped to create. But there are challenges that the Math Forum faces as well. Currently we are working on ways to push the discussion further so that the discourse of teachers like Denise can push the whole group further in their thinking. In an unmoderated discussion group this is not an easy task. We are both thinking about ways to use strong teachers as semi-moderators in these groups and ways to define the objects the teachers work with in the workshop ones that are better suited to pushing the discussion further (Sfard, 2007).

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