

An Exploration of Two Online Approaches to Mathematics Teacher Education

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## Abstract

The purpose of the present study was to examine the nature of the discourse generated by two different online approaches to mathematics teacher professional development. Thirty mathematics teachers participated in online activities involving analysis and discourse about artifacts of teaching practice. Half were randomly assigned to a group that analyzed and discussed students work samples, and the other half to a group focused upon descriptions of classroom teaching episodes. Teachers formed threads of conversation on asynchronous discussion boards as they considered the different aspects of each artifact. Within the threads, different orientations toward the reform agenda in mathematics education were shown. Some messages were strongly rooted in the reform paradigm, others in the traditional paradigm, and many others contained elements characteristic of each paradigm. The distribution and characteristics of the messages reflected teachers' frequent attempts to try to reconcile the largely incompatible paradigms undergirding reform-oriented and traditional approaches to mathematics instruction. This paper describes the nature of the discourses occurring within each group of teachers with the aim of providing empirical grounds to inform the actions of teacher educators and researchers designing online learning environments that attempt to bring teachers more fully into the reform-oriented discourse about teaching mathematics.

Teachers shape and are shaped by conversations with other professionals (Rust & Orland, 2001). Not all of these professional discourses, however, are necessarily productive. Putnam and Borko (2000) noted, “patterns of classroom teaching and learning have historically been resistant to fundamental change, in part because schools have served as powerful discourse communities that enculturate participants (students, teachers, administrators) into traditional school activities and ways of thinking” (p. 8). Mathematics education researchers have called for changes to “traditional school activities and ways of thinking” for several decades (Brownell, 1954; Hiebert & Carpenter, 1992). However, traditional practices in mathematics have remained entrenched and resistant to change (Jacobs, Hiebert, Givvin, Hollingsworth, Garnier, & Wearne, 2006). This phenomenon suggests that many teachers have been enculturated into professional discourses that value traditional rather than reform-oriented mathematics instruction.

Ross, McDougall, and Hogaboam-Gray (2002) provided a helpful conceptualization of how traditional and reform-oriented ideas in mathematics education differ from one another. They identified ten dimensions distinguishing traditional approaches to teaching mathematics from reform-oriented ones: (i) Traditional programs tend to focus heavily on number and operation to the exclusion of multiple strands of mathematics; (ii) Reform-oriented discourse emphasizes that all students have the ability to do mathematics, whereas traditional discourse does not; (iii) The main task in traditional classrooms is to apply learned procedures to decontextualized problems, whereas reform-oriented curricula emphasize learning from contextualized, open-ended tasks amenable to multiple solutions; (iv) Teaching in traditional classrooms rests on a “transmission” theory of learning, whereas reform-oriented classrooms emphasize students’ talk as a means of knowledge construction; (v) The teacher in a reform-oriented classroom is a co-learner of mathematics and not the sole knowledge expert; (vi) Manipulatives, calculators, computers, and

other such tools are featured in reform-oriented classrooms but not traditional ones; (vii) Student-to-student interaction is encouraged in reform classrooms but seen as an off-task distraction by traditional teachers; (viii) Continual formative assessments shape reform-oriented instruction, whereas assessment in traditional instruction relies solely on summative assessments; (ix) Reform-oriented teachers conceive of mathematics as a dynamic rather than static discipline; (x) Building students' mathematical self-confidence is an explicit goal in reform-oriented instruction but not in traditional.

Several types of professional development programs have been designed for the purpose of bringing teachers into the discourse surrounding reform-oriented mathematics instruction. In reviewing several different programs, Kilpatrick, Swafford, and Findell (2001) argued that the focus should be upon teachers' construction of mathematical knowledge, knowledge of students, and knowledge of classroom practice. They identified three approaches with the potential to achieve these goals:

Some of these programs begin with mathematical ideas from the school curriculum and ask teachers to analyze those ideas from the learners' perspective. Other programs use students' mathematical thinking as a springboard to motivate teachers' learning of mathematics. Still others begin with teaching practice and move toward a consideration of mathematics and students' thinking (p. 385).

This paper is an exploration of the latter two approaches in an online environment. Whereas the first approach begins with the analysis of mathematics problems, the latter two begin with the analysis of practice-related artifacts like student work samples and written cases of teaching.

### Shifting Mathematics Teachers' Discourse through Professional Development

Discussion of artifacts of practice like student work samples and teaching cases can help shift teachers' discourse toward reform-oriented ideas by helping them form empirically-grounded general conclusions and theories about teaching through the consideration of specific examples (Lampert & Ball, 1998). From the perspective that language mediates knowledge construction (Bakhtin, 1981; Wertsch, 1997), discourse among teachers about such artifacts is a key mechanism through which the formation of such general conclusions takes place. In particular, as teachers discuss practice with one another, they can challenge one another's interpretations of curriculum-related materials and prompt one another to extend local knowledge to the theoretical level (Manouchehri, 2002). Artifacts of practice facilitate such discourse by providing a common referent that allows for various interpretations to emerge during conversations (Newman, Griffin, & Cole, 1989). In the present study, the two types of practice-based artifacts of practice utilized as catalysts for discourse were student work samples and teaching cases.

#### *Discourse Catalyst 1: Student Work Samples*

Borasi and Fonzi (2002) described mathematics teacher education that focuses on student work samples in the following terms:

Teachers analyze students' thinking as revealed in students' written assignments, think-aloud problem-solving tasks, class discussions, and clinical interviews...teachers learn to observe various types of student mathematical activity and to interpret what they observe, with the ultimate goal of enhancing their students' learning opportunities (p. 53).

Various programs have incorporated elements of this approach, including Cognitively Guided Instruction (CGI) (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989), Quantitative

Understanding: Amplifying Student Achievement and Reasoning (QUASAR) (Silver & Stein, 1996), and Integrating Mathematical Assessment (IMA) (Gearhardt, Saxe, & Stipek, 1995).

Analyzing students' work samples can motivate discussions of mathematics because the artifacts analyzed contain mathematics problems themselves. Understanding the problems presented in the artifacts is a prerequisite to understanding students' thinking about them (Kilpatrick, Swafford, & Findell, 2001). For example, the CGI approach typically begins with an analysis of mathematics problems and problem types before proceeding to an examination of students' thinking about them (Carpenter, Fennema, Franke, & Levi, 1999). Analyzing samples of students' work can also motivate discourse about students. In particular, teachers have the opportunity to observe that students often have thought patterns that diverge from their own and from the structure of the discipline of mathematics (Even & Tirosh, 2002). Finally, although instructional practices are not the initial focus of professional development that deals with the analysis of students' work, shifts in teachers' pedagogical practices can occur. Teachers participating in CGI professional development, for example, adapted their practices to include teaching via problem-solving and student-to-student discourse (Franke, Fennema, & Carpenter, 1998; Lubinski & Jaberg, 1998).

### *Discourse Catalyst 2: Teaching Cases*

The case approach to teacher education is one in which, "teachers analyze and discuss 'cases' that are written narratives or video excerpts of events that are used as catalysts for raising and discussing important issues regarding school mathematics reform" (Borasi & Fonzi, 2002, p. 67). While excerpts of students' work may be included in a case, the primary focus is upon showing the social interactions between teachers and students. Programs incorporating this

approach include the Mathematics Case Methods Project (Barnett, 1991; Barnett, Goldstein, & Jackson, 1994) and Teaching for the Big Ideas (Schifter, Bastable, & Russell, 1997).

Cases designed for mathematics teacher education are generally constructed around descriptions of the teaching and learning of important mathematics problems. This allows for discussion of the complexity of concepts in the school mathematics curriculum as a group reads about teachers' and students' different approaches to the problems (Barnett, 1998). Through this process, teachers can identify the limits of their own mathematical content knowledge (Davenport & Sassi, 1995) and begin to acknowledge the need to continue their mathematical learning (Manouchehri, 2003). In addition to spurring conversations about mathematics, cases can motivate teachers' discussions of students, because cases provide the opportunity for teachers to observe and discuss how students construct mathematical knowledge and problem-solving strategies within the context of a given lesson (Friel & Carboni, 2000). Because cases contain descriptions of teachers' instructional strategies, they can also prompt teachers to analyze strategies for teaching they otherwise would not have considered, such as inquiry-oriented approaches to mathematics instruction (Friel & Carboni, 2000; Kellog & Kersaint, 2004).

### Exploring the Potential of Online Discourse

Asynchronous (time independent) online discussions can support teachers' practice-related discourse in unique ways. Perhaps the most obvious benefit is that such discussions make interactions possible among teachers separated by constraints of time and distance (Groth & Bergner, 2007). However, the potential benefits extend much further. As teachers discuss a practice-based artifact, they can participate in multiple simultaneously-formed threads of conversation, whereas participating in multiple simultaneous conversations in a face-to-face setting entails missing aspects of some of the conversations. For example, as asynchronous

online conversations form simultaneously about different aspects of a case, such as the mathematics, pedagogy, and school context it describes, teachers can participate in each of the conversations by reading all of the messages that have been posted to each of the threads (Groth, 2006). Other potential benefits of asynchronous online discussions include promoting more reflective discourse (Bodzin & Park, 2002) and fostering collegiality (Newell, Wilsman, Langenfeld, & McIntosh, 2002).

Despite the potential benefits of asynchronous online discourse, it, like any other teaching tool, is not a panacea. Participants in asynchronous online conversations don't have the benefit of being able to react quickly to non-verbal cues from others (Haavind, 2000). Merryfield (2001) observed that it can be more difficult for teachers to develop relationships across cultures when their conversations occur in an asynchronous online setting. Because online conversations constitute a relatively new tool for facilitating professional development, much work remains to be done to understand the dynamics of interaction within such settings.

### Purpose of the Study

The purpose of the present study was to examine the nature of the discourse generated by two different artifact-based online approaches to mathematics teacher professional development. Two central research questions provided focus:

- (1) What is the nature of the discourse among mathematics teachers in an asynchronous online discussion focused on examining students' written work samples?
- (2) What is the nature of the discourse among mathematics teachers in an asynchronous online discussion focused on examining a classroom case?

In the examination of each approach, particular attention was given to the extent to which each one succeeded in engaging participants in reform-oriented mathematics education discourse.



## Method

In order to provide a sense of the discourse occurring under two different approaches to online mathematics teacher education, a case study approach was used. Two parallel analyses were conducted: one describing the online discourse among a group of practitioners studying students' work samples, and another for a group studying a teaching case. Illustrative excerpts were drawn from the analyses and are presented in this paper to provide the reader with vicarious experiences of the phenomena under study (Stake, 2000). Such vicarious experiences have the potential to sharpen and refine the intuitions of teacher educators and researchers working in similar settings (Stake & Trumbull, 1982).

### *Participants*

Participants were 30 mathematics teachers from 18 different middle and high schools in the Mid-Atlantic U.S. They were selected by school administrators for participation in a grant-funded professional development program focused on the teaching of algebra. Teachers had a wide range of experience in teaching mathematics, from a minimum of one year of experience to a maximum of 34. Before participating in the online discussions described in this paper, they had face-to-face professional development experiences with one another that were intended to enhance their content knowledge in algebra. The online professional development experience described in this paper was intended to supplement their previous experiences by placing the development of pedagogical knowledge and knowledge of students in the foreground.

### *Procedure*

Software difficulties can be a hindrance to the initial development of online discussions (Salmon, 2004). In an effort to avoid such difficulties, the first author introduced the mechanics

of posting messages to the online platform that would be used for the study at an initial one hour face-to-face meeting with all study participants. At the meeting, participants were asked to access the discussion board, post a message, and reply to a few other messages that had been posted. As they did these tasks, the first author circulated about the room to help with technical problems that arose and to answer questions. The first author also collected a list of the participants' preferred email addresses and provided his own email and telephone contact information to facilitate communication over the course of the study, because he would also serve as the online moderator.

Near the end of the initial face-to-face session, expectations for participation in the online discussion were presented. One expectation was that participants should make at least four posts per week, with two coming early on each week (roughly Sunday through Wednesday), and the other two later on each week (roughly Wednesday through Saturday). At least three of the four required posts were to be replies to other participants' messages. The online discussion described in this study took place over a two week time-span. Participants were asked to spend two hours on a reading assignment, and then two hours each week making their own posts and replying to the posts of others. Using this accounting scheme, teachers were reimbursed approximately \$20 per hour (the amount varied slightly depending on the hourly rate allowed by their individual schools). At most six hours were reimbursed per individual during the two-week study period.

After the initial face-to-face meeting, 15 teachers were randomly assigned to the online group that would take the approach of examining students' work samples, and the other 15 comprised the group that would take the approach of examining cases (13 from the former group and 14 from the latter eventually actually participated when the discussions began). In an attempt to provide similar quality of instruction to each group, the materials used to catalyze discussion

each week were drawn from commercially-available artifacts from the QUASAR project.

QUASAR materials were available to support the student work sample approach (Parke, Lane, Silver, & Magone, 2003) as well as the case approach (Stein, Smith, Henningsen, & Silver, 2000). These materials were purchased and given to all participants.

Both groups of teachers were asked to begin by studying artifacts relating to the teaching and learning of rational number representations. The student work sample group began by analyzing responses to a task that began by showing a picture of 11 triangles (Parke, Lane, Silver & Magone, 2003). Five of the triangles were black, and six were white. Students completing the task were asked how many black triangles would have to be added to the picture so that half of the triangles would be black. Then, students were asked how many triangles would have to be removed from the picture so that one-third of the remaining triangles would be black. In both parts of the task, students were asked to write an explanation of how they found their answer. There were 15 written responses for teachers to analyze. Work samples contained both correct and incorrect solutions to the task. In some cases, correct answers were accompanied by incomplete explanations.

The case analysis group began by reading a case about teaching fractions, decimals, and percents using an area model (Stein, Smith, Henningsen, & Silver, 2000). The case followed a teacher, Ron Castleman, through two different class periods one day. During both class periods, Mr. Castleman asked students to shade six of the squares in a four-by-ten grid. The students were then to determine the percent, decimal, and fractional representations for the amount of the grid that was shaded. Mr. Castleman wanted students to do these tasks using diagrams as tools rather than relying upon traditional conversion algorithms. He was more successful at achieving this goal during the second class period described in the case than in the first. Embedded in the

descriptions of what transpired during the classes were several factors that contributed to the greater success of the second class period. Factors included: Mr. Castleman's reflections on the first lesson, his refusal to simplify the task for the second class, his press for justifications and explanations during the second class, and the activation of students' conceptual background knowledge in the second class.

Study participants received an email message with suggested questions for online conversation about the case and work sample artifacts. The initial email message to the case analysis group contained the following three questions, drawn from Stein et al (2000): (1) What are the main mathematical ideas of the case?; (2) What evidence is there that students learned these ideas?; (3) What did the teacher do to facilitate or inhibit students' learning of these ideas? The initial message to the group studying student work samples contained somewhat parallel questions, but adapted for the nature of the type of artifact under study: (1) What are the main mathematical ideas needed to solve the task?; (2) What evidence is there that students learned these ideas?; (3) What teaching strategies could facilitate or inhibit students' learning of these ideas? Teachers were told that they could use these as starting points for constructing posts, but were also told to feel free to pursue other potentially fruitful questions related to the artifacts.

When online discussions began, the first author's actions in facilitating the group conversations were guided by the typology of online moderator interventions described by Simonsen and Banfield (2006). Under this typology, the default moderator action is to withhold comment to allow participants to have ownership over the conversation. Once participants have made posts, the moderator may either ask participants to elaborate on specific posts or attempt to steer the group in a different direction. Borasi and Fonzi (2002) described such moderator interventions as "pulling" and "pushing" probes, respectively. Other actions within the Simonsen

and Banfield typology include validating participants' contributions and resolving participants' questions. The illustrative examples in the results section of this paper further describe specific moderator actions that occurred during the online conversations.

### *Data Gathering and Analysis*

All discussion board posts made over the course of the study were retained for analysis. There were 100 participant posts from the group focused on examining students' work samples, and 111 from the case analysis group. All messages were captured on the software platform used for the online conversations (Desire2Learn, 2006) and were then loaded into Atlas.ti (Muhr, 2004) to facilitate coding.

During data analysis, the authors coded the data collaboratively in order to capitalize on examining the data from two perspectives: that of the moderator of the discussions (first author) and that of an outside observer (second author). In the initial phase of data analysis, the authors read and informally discussed all of the messages posted to the discussion boards, looking for patterns within the conversations. During the initial analysis, it was observed that individual messages tended to fall within one of five categories ("reform" and "traditional" are used below in the way they were defined near the beginning of this manuscript by Ross, McDougall, and Hogaboam-Gray (2002)):

- Messages strongly located within reform-oriented discourse (reflective of an unqualified commitment to re-organizing instruction around one or more reform-oriented ideas for teaching mathematics);
- Messages mostly located within reform-oriented discourse (reflective of a commitment to re-organizing instruction around one or more reform-oriented ideas for teaching

mathematics, but also reflective of possible influence from traditional ideas for teaching mathematics);

- Messages reflecting equal pull from reform-oriented and traditional discourse (those that seem to be caught between two paradigms and uncertain of which one should be placed in the foreground to drive mathematics instruction);
- Messages mostly located within traditional discourse (reflective of a commitment to carrying out traditional modes of mathematics instruction, with a cursory mention of one or more reform-oriented ideas);
- Messages strongly located within traditional discourse (reflective of an unqualified commitment to carrying out traditional modes of mathematics instruction).

The five categories are indicative of the phenomenon that most professional discourses among teachers can not be classified as entirely “traditional” or “reform-oriented.” Teachers may lean toward the traditional end of the spectrum on one issue and toward the reform-oriented side on another (Groth, 2007).

During the second phase of data analysis, the authors attempted to place each discussion board message within one of the five categories identified above. At the beginning of this phase of data analysis, the placement of messages within categories was done independently. After coding the first 100 messages independently, the authors met to compare codes and notes with one another. This meeting served the function of clarifying the nature and bounds of each of the five categories by bringing up examples of disagreement in coding for discussion (Miles & Huberman, 1994). The authors then coded the remainder of the messages independently, and met once again to further clarify the meanings of each of the five categories (resulting in the finalized category descriptions provided in the previous paragraph) and which messages should be placed

in each one. All but five messages were judged to fall within one of the five categories. The results section of this paper draws upon the negotiated consensus of the two authors in regard to the placement of messages within each category.

### Results

Tables 1 and 2 summarize how individual messages fell with respect to their orientations toward reform-oriented and traditional discourses. Two patterns are immediately discernible from the tables. First of all, messages posted to the case analysis group were more closely aligned with reform-oriented discourse than messages posted to the student work sample group. Second, individual participants generally posted messages at many points along the continuum from reform-oriented to traditional mathematics education discourse. The remainder of this section describes the nature of the messages fitting each of the five categories from both groups of participants in order to illustrate particular aspects of the discourse in each group.

<INSERT TABLE 1 HERE>

<INSERT TABLE 2 HERE>

#### *Messages Strongly Located within Reform-Oriented Discourse*

Only one study participant (C9 in the teaching cases group) contributed messages that were judged to lie strongly within reform-oriented discourse. After several other participants remarked that their students prefer to work with teacher-provided algorithms rather than invent their own, the moderator asked participants to conjecture about why this may be true. In response to this prompt, C9 directly implicated traditional patterns of mathematics instruction. She stated,

I believe that students have been conditioned this way. Mr. Castleman's classroom is obviously a classroom where exploration is quite important. This is not the case in many classrooms. For many students they are used to hearing, "Today we're going to learn how

to \_\_\_\_\_.” Then they are given the formula, steps, procedure, or whatever for doing so.

With this approach, there is no room for exploration, discussion, or thinking.

In a subsequent post, she elaborated by emphasizing the importance of exploration and discussion to students’ learning.

*Messages Mostly Located within Reform-Oriented Discourse*

Four of the messages in the student work sample group were grounded mostly in a reform-oriented paradigm but reflected some influence from the traditional paradigm. For example, in describing a teaching practice he believed might be effective for helping students understand the mathematics embedded in the task included in the work sample, W2 stated,

When I kick-off my fraction unit I give my students fraction sticks. For example, a black stick would represent one whole and each individual connecting cube is one-fourth. For the activity I give each student a different color stick and tell them to exchange equivalent pieces with a partner. So, one student may exchange 2 one-eighth cubes for a single one-fourth cube. The goal is to return to your seat with a one-whole equivalent, 3 or more colors. This activity provides a nice spring board for several discussions pertaining to almost any concept with fractions.

The teaching practice described by W2 relied upon student-student interaction and allowed students to use manipulative tools. Both of these practices resonate with reform-oriented instruction. The message reflects some influence from traditional instruction, however, in the fairly prescriptive nature of the activity and the teacher’s assignment of fractional values to the manipulatives. While rooted mainly in the reform-oriented paradigm, such messages in general betrayed some influence from the traditional paradigm.



Fifteen of the messages in the case analysis group were placed in the same category. As with the work sample group, these messages were grounded in a reform-oriented paradigm but showed some influence from traditional discourse. In some cases, a reform-oriented concept was mentioned but not elaborated upon. During a conversation about “real-world” problems other than those used in the case, for example, C3 validated the ideas of another participant by stating,

Thank you so much for the great idea of gas consumption as an example of slope. You have wet my whistle to come up with other everyday examples of mathematical ideas of slope. Washing clothes – the size of the load relates to the amount of liquid soap used – the bigger the load, the more soap; the smaller the load, the less soap used.

Although the concern for incorporating “real-world” problems in instruction resonates with reform-oriented concerns, the manner in which C3 planned to use the ideas under discussion pedagogically was unclear. Without further information, it was not possible to discern the role the teacher and the students were to play in building the concept of slope from the context specified (e.g., Was the teacher to demonstrate the problem to students? Were these to be “application problems” that would be used only after “basic skills” had been learned?). This message, like others in the same category, reflected a commitment to some aspect of reform, but did not differentiate the ideas completely from traditional ones.

#### *Messages Reflecting Equal Pull from Reform-Oriented and Traditional Discourse*

Seventeen messages in the work sample analysis group did not seem to be rooted firmly in either the traditional or reform-oriented paradigm of instruction. Both paradigms seemed to exert equal influence on the content of these posts. In the student work sample group, a fair amount of discussion ensued when some individuals suggested that using manipulatives would help students understand the concepts embedded in the given task. Many of the messages in this

strand of conversation contained a balance of traditional and reform-oriented ideas, as in the following comments made by W3:

In this task, pattern blocks could be used as an aid for students who did not master the concept. To help students understand the concept of half, two groups of different shaped blocks could be used and they would model half as a one-to-one ratio with none left over. If there were leftovers, they would have to either add or remove a block as the written task asked students to do. The same idea could be used for thirds, etc. By matching in groups, the concept of factors is enforced.

In this message, an interest in reform-oriented instruction is suggested by the use of manipulatives. Notably absent, however, is any acknowledgement that students' reasoning patterns when working with the blocks may be different from that of the teacher. Instead, the manner in which the pattern blocks are to be manipulated is largely prescribed by the teacher. Messages like this reflected no firm commitment to either reform-oriented or traditional ideas for teaching mathematics.

Messages midway between reform and traditional discourse were quite prevalent among the group discussing the teaching case. They accounted for 57 of the 111 messages posted to the group. The following posts are typical of the many included in this category (these two messages below were part of a larger conversation that was sparked by the degree of freedom the teacher in the case allowed students in solving problems):

C11: 'Letting go' is a personal challenge for me. I don't like to see my children struggle and worry that they will give up completely if they cannot figure a problem out. It is difficult for me to simply let them struggle for a few minutes because I fear losing their attention altogether. During the times that I do actually let my children sit and ponder for

a few minutes, they can come up with some wonderful ideas. I just need to get myself to a point where I feel like that is OK.

C5: Exploration is a great way to introduce a lesson or unit. I feel it gives students a concrete reference to fall back on. I do feel that an exploration exercise does need to be followed by what may be a more traditional lesson to make sure the students understand what they were supposed to be discovering.

Reading about students' success with a discovery-oriented lesson seemed to create a dilemma for the teachers in the group. While many messages, like those above, embraced idea of student discovery, they were hesitant to completely surrender traditional ways of thinking about mathematics instruction. The evidence from the case seemed to be sufficient to spur some to further consider reform-oriented ideas like student discovery, but not enough to completely dislodge traditional ways of thinking about teaching mathematics.

#### *Messages Mostly Located within Traditional Discourse*

Twenty-six of the messages in the student work-sample group were located mostly within traditional discourse. In this group, several posts were dedicated to talking about ideas for grading summative assessment items and raising students' scores on them. Such conversation was spurred by participants' observation that the work sample task resembled some of those given on the high-stakes end-of-course assessment administered by the state. This focus reflected the traditional idea that assessment is something done *to* students rather than *for* students (NCTM, 2000). Among these posts, however, were some that included elements of reform-oriented discourse. As part of a discussion for raising students' scores on the high-stakes summative assessment administered by the state, W4 wrote,

I also agree that discussing student samples as a class truly helps the students improve their understanding. Last school year, we would begin by looking at a perfect answer and discussed the parts that made it a perfect answer. Then, we would look at answers that had weak explanations or incorrect answers. As a class, we would work on fixing the answers so that the score would become a perfect score. When using student work, I would try to retype or rewrite the answers so that the students could not identify the handwriting. Looking at answers that have earned different scores is a powerful and useful tool in teaching students how to correctly answer BCRs.

(Note: BCR stands for “Brief Constructed Response.” It is an acronym used by the state in reference to a type of item on the high-stakes summative assessment that requires students to write to explain their answers to problems). Although the tight focus on raising scores on summative assessments (“getting a perfect answer”) runs in opposition to the reform-oriented concern of learning mathematics with understanding, the post does mention an attempt at building student-student interaction. The primary purpose of the student-student interaction, however, was portrayed as becoming effective test takers rather than learning mathematics. The primary concern in this post and others like it aligned with a traditional paradigm of mathematics instruction, although an incidental nod to reform-oriented ideas was given.

A similar number of messages in the case analysis group were categorized in the same manner. Twenty-three of the messages in this group were primarily concerned with carrying out parts of the agenda for traditional instruction, but incidentally promoted some aspect of reform. The following excerpt from an exchange between two teachers, for example, is grounded in the traditional notion that some students are less capable of constructing mathematical knowledge

than others, but brings in discussions of efforts to implement the reform-oriented idea of “discovery,” because it was illustrated by the case:

C9: If I have a class where the majority of my kids are above or at least at grade level, usually I can still take the time for the discovery and discussion. But when I have the lower ability students and I’m standing there waiting for someone to say something, anything at all, I just tell myself that that time can be used for just instruction and practice.

C1: I get frustrated just standing and waiting at the board too. I try to give prompts, like Mr. Castleman, but my lower level kids just sit there and wait for my breaking point. What really gets on my nerves is having one or two students in the class who do not know what to do and they are constantly yelling the answers out.

Both comments implicate students’ ability levels for the failure of attempts at “discovery” lessons. Notably, both teachers had expressed ideas more aligned with reform-oriented instruction earlier in different strands of conversation. The frustration this particular exchange seems to stem from lack of knowledge of how to execute discovery-based lessons, but that lack of knowledge is not identified as a cause of the failure of the lessons. Therefore, in these two messages, as well as the others like them, reform-oriented ideas of teaching and learning mathematics were overshadowed by dominant traditional views.

#### *Messages Strongly Located within Traditional Discourse*

Most of the messages in the student work sample group (52 out of 100) were strongly grounded in an aspect of traditional discourse about teaching and learning mathematics. Such messages, unlike those in the previously-described category, did not even include passing references to aspects of reform-oriented discourse. The predominant theme among these

messages was concern about the nature of open-ended items on the high-stakes summative assessment administered by the state. The following dialogue excerpts are illustrative:

W2: When we score our ECRs (Extended Constructed Response) as a team we score each of the ECRs holistically. I'm concluding that the triangle task was an ECR.

W9: When we grade tests, we assign each question a point value. Then, we simply divide the number of points earned by the total number of points available. A multiple choice question would be worth 1 point...BCRs worth 3 points, and ECRs worth 4 points.

W6: When I grade an ECR or BCR that is part of a test I do actually grade them separately out of either 3 or 4, then they are weighted as 3 or 4 points out of the test. I know this makes their value greater, but I feel they need to be since they are heavily weighted on our county tests and of course the state test.

W9: It's my understanding that when scoring an ECR – you can't necessarily assign an individual point value to each bullet in Part B – sometimes it may work out that it is possible to do it that way – however, other times you have to apply the 3 points to the overall answer.

The excessive amount of concern with carrying out BCRs and ECRs stifled many of the other possible conversation topics that could have arisen from the student work samples. Rather than focusing on the nature of students' thinking, many messages concentrated on mechanical aspects of teachers' thinking in assigning grades to summative assessment items. These types of messages made no apparent contribution to moving the discourse toward consideration of aspects of the reform-oriented paradigm for mathematics instruction.

A much smaller number of messages (10 out of 110) in the case analysis group neglected mention of any aspect of reform. Messages that remained strictly within the traditional paradigm

in this group tended to espouse the theory that knowledge can be directly transmitted from student to teacher. The following exchange among teachers was concerned with the correct formula to give students in order to deal successfully with some of the mathematics content (percentages) embedded in the case:

C8: I usually start with the formula  $R = P/B$ . What about you?

C10: Hi C8, I also use the percentage proportion formula. As a cute little rhythm that translates word problems it goes like this:  $IS/OF = \%/100$

C9: I like your little rhyme. I think I'll use it when teaching the percentage proportion formula.

Although a few messages also were devoted exclusively to scoring and administering summative assessment items related to the state's high stakes test, as with the work sample group, the influence that the topic exerted on the discourse was not nearly as stifling.

#### Discussion and Implications for Teacher Education

Calls have been made for more research describing the results of using practice-based artifacts in teacher education (Grossman, 2005; Putnam & Borko, 2000). The present study helps answer those calls by describing outcomes associated with artifact-based online discourse among two groups of mathematics teachers. Particular attention was given to analyzing discussions sparked by different catalysts, because the initial seeds of conversations exert influence over the future directions conversation participants may pursue (Smitherman, 2005). This section offers observations on the successes and failures experienced in this particular setting, with the goal of informing the work of those considering similar approaches to teacher education.

*Observations about Reform-Oriented Online Discourse*

The overarching goal of the professional development described in this paper was to help bring teachers into the discourse surrounding mathematics education reform. The case analysis group engaged in such discourse to a greater extent than the student work sample group. To some extent, then, it seems that the case was a more effective initial seed for conversation than the student work samples. The case helped motivate discussion about specific reform-oriented teaching strategies (Ross, McDougall, & Hogaboam-Gray, 2002), while the student work samples sparked a great deal of discussion about procedures for grading summative assessments. This does not mean, however, that the same results would occur in different settings. The student work samples in this study fell victim to bearing too much resemblance to items included on high-stakes summative assessments the teachers were required to prepare students to take. The same work samples may prove to be more successful tools for motivating reform-oriented conversations in settings where teachers do not operate under this constraint. This highlights the fact that the types of conversations catalyzed by any given artifact of practice will be dictated, in part, by the specific circumstances of the group of teachers studying the artifact. A general implication is that teacher educators can better understand teachers' behaviors in such a setting by realizing that the online community is just one of the professional discourse communities that teachers inhabit. There is value in taking teachers' institutional settings and constraints into account (Cobb, McClain, de Silva Lamberg, & Dean, 2003) when interpreting their online interactions.

It also seems that the work samples may have been more effective tools for facilitating reform-oriented discourse if used in a face-to-face meeting of the group, or even a synchronous meeting, rather than in an asynchronous online conversation. Although the ability to form



multiple simultaneous threads of conversations can be considered a strength of asynchronous conversations because it allows participants to take part in numerous parallel discussions of different facets of an artifact (Groth, 2006), it can also be a weakness. Once the work sample group started a strand strictly about conducting and grading summative assessments, the strand snowballed and took on a life of its own. In face-to-face or synchronous online settings, the moderator exerts more influence over group conversations because there is a single stream of discourse to steer rather than multiple streams. In a face-to-face or synchronous setting, there may have been greater opportunity to draw participants' attention back to the mathematics, the nature of students' thinking, and teaching strategies related to the work samples.

Another striking feature of the present study was that although the case discussion more closely aligned with reform-oriented discourse than the work sample discussion, most of the messages in the case analysis group seemed to be caught between two paradigms for mathematics instruction rather than firmly rooted in either one. Even some individuals who reflected a tendency toward reform-oriented discourse some times betrayed orientations toward traditional discourse at others. Given that traditional ideas are still dominant in many discourses among mathematics teachers (Jacobs, Hiebert, Givvin, Hollingsworth, Garnier, & Wearne, 2006; Putnam & Borko, 2000), it seems likely that teachers caught between two paradigms during professional development will gravitate back toward traditional ideas when operating within their school environments. Since a single artifact-related discussion that leaves teachers caught between two paradigms is not sufficient, it should be kept in mind that artifacts of practice should be incorporated into a curriculum so they build on one another in a coherent fashion (Lampert & Ball, 1998). Otherwise, tentative conclusions reached during a single conversation

will likely be counteracted by voices within the other, possibly more influential, offline discourse communities teachers inhabit.

### *Incidental Observations*

As we analyzed the potential of both types of artifacts to produce reform-oriented online conversations among teachers, we made some observations about teachers' willingness to engage in disagreements and conversations about mathematics content. Although these observations were incidental to the primary analysis conducted, we felt that it may be valuable to share the observations in this section in order to motivate additional lines of investigation for researchers working on similar projects.

As we initially read the discussion board messages, we frequently discussed the fact that there were no vivid instances to document of teachers disagreeing with one another's interpretations of the artifacts. There were various opportunities for individuals to disagree with one another, especially in the online case discussion, where a wide range of commitment to reform-oriented instruction was reflected in participants' posts. One would hope that a community of teachers could establish the conversational norm of disagreeing in a productive manner early on in the formation of the community, in order to fully capitalize on the learning potential of conversations about artifacts of practice. If such a norm is not established, professional development conversations run the risk of degenerating into situations where one opinion or interpretation is considered just as good as another (Ball, 1996). Critical analyses of one another's beliefs and practices are essential to make discourse among teachers productive (Manouchehri, 2002). It would seem that the online environment might help teachers feel more at ease with disagreement and argumentation, as such a setting can help remove inhibitions about speaking that may be present in a face-to-face setting (Joinson, 1998). However, hesitation to

disagree may have arisen from the fact that teachers had met each other face-to-face previously. It is an open question whether or not an online community of teachers who had never met face-to-face would engage in more disagreements.

Another feature that was missing from the conversations among both groups was consideration of the mathematics in the tasks contained in the artifacts. A similar lack of mathematical knowledge construction among teachers while studying artifacts of practice was observed by Derry, Wilsman, and Hackbarth (2007). The lack of collaborative mathematical knowledge construction in the present study may have been caused by numerous factors, including: (i) The mathematics embedded in the artifacts were not challenging enough to motivate such conversations, (ii) Teachers felt that examining instructional strategies and students' thinking was more pertinent to their learning; (iii) The online environment made it awkward to communicate with mathematical representations; (iv) Teachers were hesitant to reveal content knowledge deficiencies. There could also have been other factors contributing to the lack of mathematical conversations. Therefore, this study raises an important question: what factors inhibit or encourage teachers from discussing mathematics embedded in practice-related artifacts? If such artifacts are to realize their full potential as tools for mathematics teacher education, learning environment designers should aim to spark content-based discussions.

### Conclusion

In summary, this study raises issues teacher educators should anticipate when using artifact-based approaches for online professional development. Decisions about how to facilitate these types of discussions with different groups of teachers can be informed by the description of what transpired in these cases along with the reader's knowledge of his or her own situation. The study raises some questions for teacher educators to ask themselves when designing an artifact-

based, online discussion environment, such as: (1) Is the artifact(s) meant to catalyze the conversation connected to teachers' curricular responsibilities, yet divergent enough to push conversation in directions teachers would not pursue on their own?; (2) Is it more desirable to create multiple streams or a single stream of discourse to discuss the artifact(s)?; (3) How will the artifacts that are introduced build upon one another to bring teachers more fully into reform-oriented discourse?; (4) How will a norm of productive critical analysis of one another's interpretations about an artifact be established among the group?; (5) How will teachers' attention be directed toward the mathematics embedded in the artifact? Viable answers to these questions should be formed by teacher educators as they engage teachers in the types of online discourse described in this paper.

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Table 1

## Distribution of Messages in Student Work Sample Group

Participant	Messages	Messages	Messages	Messages	Messages
	strongly located	mostly located	reflecting equal	mostly	strongly
	within reform-	within reform-	pull from	located within	located within
	oriented	oriented	reform-	traditional	traditional
	discourse	discourse	oriented and	discourse	discourse
			traditional		
			discourse		
W1	0	1	3	5	3
W2	0	1	1	1	3
W3	0	0	3	2	4
W4	0	0	0	5	3
W5	0	0	2	0	7
W6	0	0	0	2	6
W7	0	2	6	2	1
W8	0	0	0	2	6
W9	0	0	0	1	6
W10	0	0	0	2	3
W11	0	0	0	1	5
W12	0	0	2	2	4
W13	0	0	0	1	1
TOTAL	0	4	17	26	52

Table 2

## Distribution of Messages in Teaching Case Group

Participant	Messages	Messages	Messages	Messages	Messages
	strongly located	mostly located	reflecting equal	mostly	strongly
	within reform-	within reform-	pull from	located within	located within
	oriented	oriented	reform-	traditional	traditional
	discourse	discourse	oriented and	discourse	discourse
			traditional		
			discourse		
C1	0	2	4	4	1
C2	0	1	7	3	1
C3	0	3	4	1	0
C4	0	0	6	1	0
C5	0	1	3	2	0
C6	0	0	6	1	2
C7	0	0	1	0	0
C8	0	1	1	1	3
C9	2	3	1	2	1
C10	0	4	6	0	1
C11	0	0	6	2	0
C12	0	0	1	3	0
C13	0	0	7	3	1
C14	0	0	4	0	0

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TOTAL	2	15	57	23	10
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