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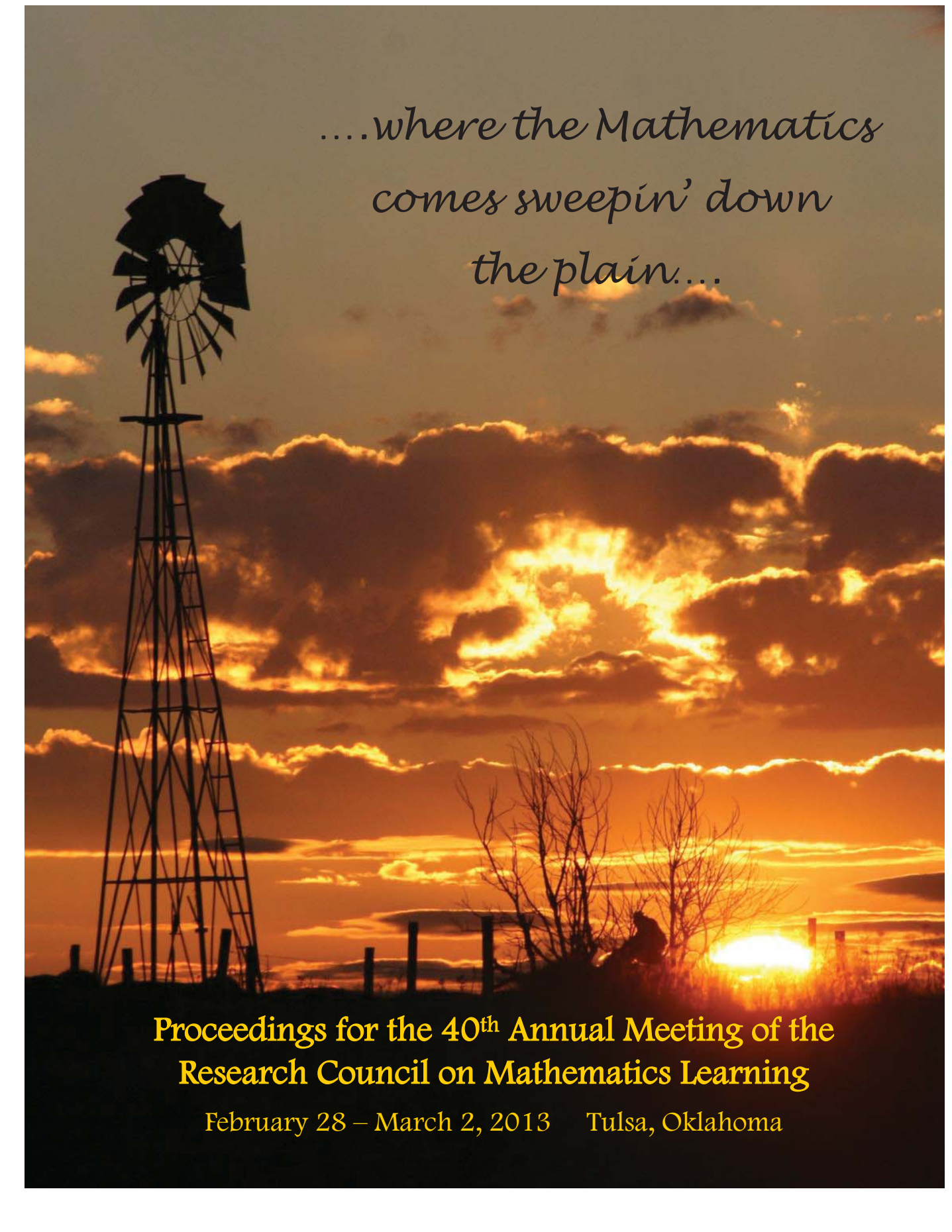
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*....where the Mathematics
comes sweepin' down
the plain....*

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PREPARING K-10 TEACHERS THROUGH COMMON CORE FOR REASONING AND SENSE MAKING¹

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There looms an uncertainty about the Common Core State Standards for mathematics for many teachers. Teachers have indicated that they want professional development (PD) focused on learning about the new standards (Bostic & Matney, in press). This manuscript describes PD programs for K-10 mathematics teachers and offers results from one activity aimed to help teachers unpack the Standards for Mathematical Practice (SFMP). Four major themes arose from interpretive analysis of teachers' perceptions of the SFMP. These findings suggest (1) the PD supported teachers to make sense of the SFMP and (2) teachers may have misperceptions about the SFMP that require further PD.

Standards for Mathematical Practice

Mathematics instruction in the era of Common Core State Standards for mathematics (CCSSM; Council of Chief State School Officers [CCSSO], 2010) will require teachers to reevaluate their current instruction (National Council of Teachers of Mathematics [NCTM], 2010). The CCSSM built upon decades of work “to define the mathematics that students need to know and be able to do” (NCTM, 2010, p. ix). A critical element of the CCSSM is the overarching emphasis given to the Standards for Mathematical Practice (SFMP). The SFMP offer descriptions of behaviors that students should demonstrate while learning mathematics. The SFMP were created from two foundational texts: *Principles and Standards for School Mathematics* (NCTM, 2000) and *Adding it Up* (Kilpatrick, Swafford, & Findell, 2001). NCTM’s (2000) process standards are problem solving, reasoning and proof, communication, connections, and representation. The notion of mathematical proficiency includes conceptual understanding, procedural fluency, adaptive reasoning, strategic competence, and productive disposition (Kilpatrick et al, 2001). Elements from the process standards and the mathematical proficiency are evident in the SFMP. Unfortunately, these ideas are not evident in every classroom. Thus, professional development must be designed to enhance teachers’ understanding of the SFMP and ways to encourage these behaviors in their mathematics classrooms. These behaviors are not

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isolated and often occur in tandem with one another because they are interrelated behaviors (CCSSO, 2010). For example, making sense of problems and looking for mathematical structure are likely to occur during a problem-solving session. In order for students to elicit behaviors indicative of the SFMP, teachers must design and enact instruction that allow students to wrestle with mathematics content and its applications in an environment that supports and sustains meaningful engagement with mathematics.

There is no prescribed set curriculum or pathway for teachers to encourage these behaviors in their students; however, worthwhile tasks and mathematical discourse provide a vehicle for supporting students' mathematical thinking (NCTM, 2007). Video analyses of USA teachers' instruction indicates that generally speaking, teachers are not promoting the process standards or mathematical proficiency (Hiebert et al., 2005), much less the SFMP. Hence, mathematics teacher educators should provide professional development that assists K-12 mathematics teachers' understandings of the student behaviors found in the SFMP and how those behaviors can be promoted through their instruction. The purpose of this paper is to discuss K-10 mathematics teachers' perceptions about the SFMP.

Professional Development

Teachers need professional development during the transition to the CCSSM. This PD “will require practical, intensive, and ongoing professional learning - no one-off ‘spray and pray’ training” (Hirsh, 2012). An underlying goal of most professional development is to enhance teachers' understanding of content, pedagogy, or content-focused pedagogy. Results from a national sample of more than 1,000 mathematics and science teachers indicated that three factors are most likely to influence teachers' practices: (1) connection to teachers' prior experiences, (2) alignment with standards, and (3) opportunities to share ideas with other teachers (Garet, Porter, Desimoney, Birman, & Yoon, 2001). Engaging teachers with mathematics content in a way that fosters hands-on learning and finding ways to integrate PD activities into a teachers' daily life led to longer lasting positive instructional outcomes (Garet et al., 2001). Thus, mathematics teacher educators ought to focus on these factors to promote coherent PD.

A metaanalysis of PD suggests that there are some key features to designing effective inservice teacher education (Guskey & Yoon, 2009). First, workshops and summer institutes that focus on implementing research-based instructional practices, active learning, and opportunities to adapt these practices in the classroom were highly correlated with positive

student outcomes. Second, PD led by university faculty or consultants outside of a school district tended to foster more positive outcomes than PD delivered by school personnel. Third, purposefully structured and directed PD that focused on content, pedagogy, or both and lasted more than 30 contact hours was positively associated with improving students' outcomes. Fourth, activities that encourage teachers to adapt a variety of practices to a content area are better than encouraging a set of "best practices". That is, teachers ought to learn how to adapt to novel situations and use a variety of teaching tools. Fifth, effective PD supports teachers' content or pedagogical content knowledge and the PD is situated in knowledge drawn from how students learn. Finally, effective PD includes follow-up activities after the main professional development. With these features in mind for designing successful PD, two PD projects were conducted in a Midwestern state in an effort to prepare teachers to implement the CCSSM. This manuscript provides insight into one research question stemming from an activity conducted during the projects: What are teachers' perceptions of the SFMP? Teachers' perceptions about the SFMP will help mathematics teacher educators design and implement PD intended to focus on the SFMP.

Method

Context of the Professional Development

This manuscript synthesizes results of an activity that occurred during two grant-funded yearlong projects. Each author was a project director for one PD program and co-primary investigator on the other. Teachers met four times for four-and-a-half hour sessions between March – April 2012. Next, participants and instructors met for eight 8-hour days during June 2012. Finally, teachers met twice face-to-face for four-and-a-half hour sessions between August – October 2012. Instructors also provided numerous online assignments and facilitated online interactions between March – October to support teachers' understanding of the SFMP. Since the teachers performed the same SFMP unpacking activity in each of their respective PD programs over the course of two meetings, data from the two programs are combined.

Every program included teachers from a high-needs district (i.e., more than 20% of students come from families below the poverty line and a large percentage of teachers are teaching out of their licensed field). Generally speaking, the aims of the PD projects included (1) making sense of the SFMP, (2) exploring inquiry through worthwhile tasks, mathematical discourse, and appropriate learning environments, and (3) implementing classroom-based tasks that aligned

with the CCSSM. Teachers read and discussed chapters from NCTM books and completed various assignments including reflective journaling, writing, enacting, and reflecting on CCSSM-aligned mathematics lessons, and solving mathematics problems.

Participants

One grant-funded project served 23 grades K-5 mathematics teachers while the other grant-funded project supported 23 grades 5-10 mathematics teachers. The K-5 and grade 5-10 teachers met separately due to geographic constraints. Teachers came from urban, suburban, and rural school districts. Teachers consented to being video recorded during the PD.

Procedures

Unpacking the SFMP activity. The teachers were given an activity to make sense of the SFMP during the third and fourth meeting dates of their respective PD meetings during Spring 2012. They were assembled into groups of two to four participants. Groups were strategically made so that teachers shared ideas with others teaching similar grade levels but located in different school districts. Elementary teachers were organized into grades K-2 and grades 3-5. Middle level and secondary teachers were organized into grades 5-7 and grade 8-HS teachers. Teachers were asked to describe the SFMP in a manner that the following three kinds of people might understand: (1) a child in their respective grade levels, (2) a parent or administrator, and (3) a fellow teacher of mathematics. After creating the description, they were expected to role-play a classroom scenario depicting an aspect of the SFMP provided to them. Groups were encouraged to behave as the teacher and students or role-play a scenario with only students. Finally, the rest of the teachers shared whether and/or to what degree the SFMP was evident in the skit. The instructors synthesized teachers' ideas during this final share time. Teachers' descriptions and role-plays were videotaped and later transcribed.

Data Collection and Analysis

The unpacking of the SFMP activity was videotaped. Videotapes provided adequate visual and audio evidence of the interactions, cues, writing, technology and expressions used during the role-play and ensuing conversations. Data were analyzed using interpretive analysis (Hatch, 2002). First, videos of the unpacking activity were transcribed. A matrix was created to organize ideas during the coding process. Each SFMP was ascribed a column and each group of teachers was assigned a row. Second, three coders (two mathematics education faculty and one graduate research assistant) watched the videotapes and read transcripts simultaneously to

familiarize themselves with the data. Videotapes were paused after each role-play to allow the coders to discuss the activity and share ideas. Initial ideas about each group's role-play were recorded as memos to reflect on during iterative and subsequent analyses. Third, the coders reviewed the memos within the matrix for overarching themes that transcended across groups, grade levels, and/or SFMP. Fourth, themes were reexamined for substantial evidence and a paucity or lack of evidence. Themes were retained when there was substantial evidence from the videotapes and/or transcripts. The fifth and final stage in the process was to rewrite the themes as complete sentences and consider viable representations to convey the coders' interpretations of teachers' perceptions of SFMP through the activity.

Results

Four themes were revealed as a result of the interpretive analyses. The first theme was that there is a lack of evidence that teachers understand SFMP #1. Teachers' role-playing activities provided little evidence of any behavior described in this standard. For example, the high school group of teachers role-played a scenario in which students worked with system of equations using a graphing calculator. Language within SFMP #1 stated that "older students might, depending on the context of the problem...change the viewing window on their graphing calculator to get the information they need" (CCSSO, 2010, p.6). Their task was meant to be an exercise rather than a problem. They interpreted expanding the graphing window to examine a system of equations as evidence of this standard. Unfortunately, these high school teachers perceived that merely changing the viewing window while working on an exercise is sufficient evidence of SFMP #1. A critical component to demonstrating SFMP #1 is providing students with a worthwhile task that is problematic.

A second theme that emerged was that the norm of classroom environments impact the depth and quality of the SFMP that may be exhibited. For example, the group of intermediate elementary teachers role-played SFMP #4: Model with Mathematics. Specific to this role-play, the teachers enacted norms such as (a) students are expected to discuss the effectiveness of the model and its representation, (b) students are expected to discuss the mathematics within the model, and (c) reason quantitatively as described in SFMP #2. Other sociomathematical and mathematical norms were displayed in other groups' role-plays such as (a) commenting on others' ideas rather than the person and (b) exploring and discussing alternative strategies, models, and solutions. An example of teachers' misperceptions was evident in middle school

teachers' role-play of SFMP #4. A participant acted as the classroom teacher while two other group members behaved as students. The teacher offered a verbal exercise and then asked students to solve it. The teacher used an initiate-respond-evaluate (IRE) discourse pattern (see Durkin, 1978-1979) and proceeded to focus students' inquiries into finding a solution to the task instead of creating and evaluating the model. The teacher positioned himself as the authority and did not take up students' ideas and explore them. Instead, he perceived his goal was to find the solution rather than explore the appropriateness of the model. This role-play and others made it clear that classroom norms impact students' ability to adequately demonstrate practice standards.

A third and important theme was that teachers struggled with the notion that the SFMP are written for students to demonstrate. This is clearly evident in the language of the SFMP because every standard begins with "mathematically proficient students..." (CCSSM, 2010, pp. 6-8). Thus, students should be the ones showing these behaviors. The teacher is the facilitator in the classroom who creates a context for students to engage in these mathematical behaviors. The videos of the role-play consistently showed that teachers struggled with determining what it is students should exhibit as evidence of the behaviors in the practice standards. The intermediate group given SFMP #7 employed the circles and stars activity (Burns, 1991) to model thinking about multiplication. That is, does a times b describe a groups of b items or a items collected into b groups? The teacher in the role-play showed students how to group the items and did not allow students to wrestle with this mathematics question. Similarly, the middle school group role-played an example of a verbal exercise given to students as an example of SFMP #7 (i.e., How many M&Ms are needed if there are 15 students in a class and each student should receive nine M&Ms?). Again, the teacher led the instruction using an IRE format and directed students' thinking with guiding questions. Students were not provided with a problematic task much less time to wrestle with it, and were not expected to demonstrate the behaviors indicated in the SFMP. Teachers often perceived their role was to demonstrate the behaviors and encourage students to notice how the teacher behaved mathematically.

The fourth and final theme revolved around teachers' mathematics experiences. That is, the kind of mathematics teaching involving the CCSSM, specifically the SFMP, were not experiences the teachers had as students. It was difficult for teachers to interpret the SFMP and implement them in their role-play activity as the CCSSM authors might desire. Teachers shared during conversations following the role-play activity that their mathematical experiences in

school were composed of completing exercises and engaging with the teacher in an IRE format. These four themes provide insight into teachers' perceptions of the SFMP and also point to features that mathematics teacher educators should consider when enacting PD focused on the SFMP.

Implications

This PD activity and its results ought to impact how teacher educators design and implement professional development. One issue is that teachers have not personally experienced mathematics learning behaviors like those described in the SFMP. The SFMP do not dictate curriculum or teaching but they do provide ideas for the types of behaviors that mathematically proficient students ought to exhibit during classroom instruction. If teachers are expected to encourage these behaviors in their students then they may need to experience mathematics instruction that allows them to engage in these behaviors. PD may help mathematics teachers at all grade levels make sense of mathematics instruction that supports students' appropriate mathematical behaviors.

Limitations

This study has some limitations that impact the results and conclusions. First, the interpretivist approach to analyzing data was selected because it allowed the coders to make sense of the data and draw logical conclusions. It is possible that another coder or set of coders might draw different conclusions. Qualitative approaches allow researchers to draw on their lenses and frames of reference to make sense of experiences in the world. The results offered here are not generalizable to all teachers and are particular to this set of teachers. A second limitation is the sample of teachers. These teachers volunteered to participate in mathematics professional development, which is an indicator of motivation to improve oneself. Our themes might differ if the sample included teachers who were less motivated to do PD. Furthermore, teachers with different prior (i.e., mathematics and mathematics content) knowledge and experiences teaching in other contexts (e.g., metropolitan districts) might lead to different results.

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