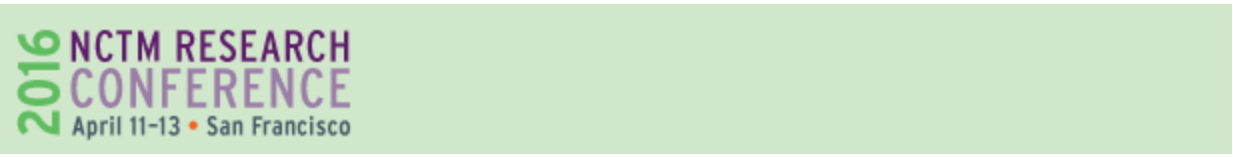

Paper Title: Teachers as problem solvers: Insights from professional development

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Session Title: Teachers as problem solvers: Insights from professional development

Session Type: Brief Research Report

Presentation Date: Wednesday April, 13, 2016: 2:45-3:15

Presentation Location: San Francisco, California

Teachers as problem solvers: Insights from professional development

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Abstract

This exploratory phenomenological study centers on secondary educators' problem solving experiences with the use of open-ended tasks. An analysis of a three-week professional development program focused on supporting middle school teachers' conceptual and procedural knowledge through a firsthand involvement in problem solving processes. Data from teachers' journals and written reflections are presented to explore educators' personal experiences as learners and teachers of problem solving. Preliminary findings reveal that teachers encountered a range of opportunities and challenges as they positioned themselves as both learners and teachers of mathematical problem solving. Select cases are discussed and a proposed framework for understanding the complexities of their experiences is presented.

Keywords: professional development, problem solving, teachers as problem solvers

Teachers as problem solvers: Insights from professional development

Current practices in mathematics hold problem solving, reasoning, and communication processes at the core of teaching and learning. Existing standards documents emphasize this view by encouraging teachers to implement classroom practices that enhance students' cognitive and social development. Such practices include the posing of real-world problems, developing plans for solving problems, using multiple representations, and providing opportunities to justify mathematical thinking (CCSSM, 2010). Although research supports the perspective that such practices should form the centerpiece of mathematics instruction, the implementation of problem solving methods is still a challenge in today's classrooms.

Research shows that instructional practices needed to implement problem solving pose challenges to teachers who themselves learned mathematics in more traditional settings. These teachers likely have had limited experiences learning mathematics in this manner, which may in turn lead to personal conflict about problem solving (Sakshaug & Wohlhuter, 2010; Smith, 2000). Thus, it becomes critical to teachers' growth to enhance their content and pedagogical knowledge of problem solving through professional development opportunities. Such experiences can provide teachers with valued dialogue that develops personal mathematical understandings and restructures instructional beliefs and practices (Crespo & Featherstone, 2006). However, introducing new ways of thinking about and implementing mathematics instruction may create cognitive dissonance for teachers, where conflicting views between old and new practices can emerge (Buschman, 2004; Smith, 2000). To better design professional development about problem solving and better support teachers in implementing it in their classrooms, we aimed to provide teachers with rich problem solving experiences and explored their involvement in the practice of problem solving. Such activities have the potential to "help

teachers reflect on their identities as mathematics learners and to understand their role in the development of their students' mathematical identities" (McCulloch, et al., 2013, p.1). Moreover, the study of teachers as problem solvers can be distinguished from the study of students as problem solvers in that in-service teacher learning is rarely divorced from the considerations of teaching (Nipper, et. al, 2011).

While the current literature accounts for teachers' improvement in implementing and reflecting upon problem solving instruction, only a small body of work centers on the idea of teachers as problem solvers (Borko et al., 2000; Brahier & Schaffner, 2004; Crespo, 2006; Edens, 2000; Kersaint & Chappell, 2001; Sakshaug & Wohlhuter, 2010). In other words, little work has been focused on engaging teachers in experiences similar to those that students may have in a problem solving context with the purpose of helping teachers understand student needs, as well as advancing their personal content knowledge. The purpose of this study was to immerse middle school teachers in the problem solving process and examine their experiences as both learners and teachers. We asked the following question: what opportunities and challenges do teachers experience as problem solvers during a professional development workshop centered on problem solving?

This study draws from cognitive and constructivist theories of learning since these perspectives embrace the notion that knowledge is constructed through an ongoing interaction between the individual and the social setting (Shepard, 2000). In these frameworks, learning is seen as an intricate social-individual development that relies on the participants' prior experiences to make sense of new knowledge. Exploring teachers' understandings of problem solving through their engagement in group activities, discussions, and self-reflection aligns with

this philosophy. Additionally, the frameworks serve to explain mathematical teaching perspectives and practices by grounding such actions as multifaceted social learning activities.

Methods

Study Background

The study involved fifteen middle school teachers who participated in a grant-based professional development summer program. The teachers had varied amounts of teaching experience and came from multiple schools across various high-need districts in a large southwestern city. As a group, the participants exhibited low algebraic reasoning and problem solving scores on the Algebra Ideas Pre-Assessment on the Diagnostics Teachers Assessment in Mathematics and Science (DTAMS). Throughout the three-week period, teachers participated in problem solving experiences, which consisted of daily open-ended tasks that were mostly appropriate for middle-school students, group discussions, and individual reflections. Furthermore, teachers worked collaboratively to extend grade-level specific math problems to implement in their classrooms. These problem solving experiences were intentionally structured by the facilitators to follow the framework for orchestrating mathematical discussions outlined by Stein et al., (2008). The program concluded with teacher model-lessons and final reflections of their experiences in the program.

Data Collection

All the data collected for this stage of the study came from the professional development summer program. The artifacts collected through the course of the study were: (1) teachers' daily personal reflections, (2) artifacts from their work on open-ended mathematics problems, (3) researcher field notes taken during the course of the professional development session, (4) reflections from the facilitators about their intentionality and observations, and (5) videos of

teachers' final model lessons of problem solving tasks. We asked each of the participants to record all his or her work and answer the reflection questions in a single notebook, which we collected at the end of the summer program. These journals contain their entire written problem solving work, as well as their responses to reflection questions regarding their problem solving experiences. This paper focuses specifically on the participants' daily written journal responses and their final reflections (Table 1).

Table 1
Teacher Reflection Questions

Daily Reflections

First half of summer program:

1. What was your initial approach to solving the problem and how did it change as you worked?
2. What did you do when you were confused or stuck?
3. How did you convince others that your solution/strategy was valid?

Second half of summer program:

1. Describe your overall process for solving this problem. What was your first instinct and how did that change and you worked?
2. How did you feel about this problem as a problem solver?
3. What is your perspective of this problem as a teacher?

Final Reflections

1. Describe your experiences over the last three weeks as a problem solver?
2. Do you see yourself engaging students in problem solving activities in your classroom? Explain why or why not.

Data Analysis

We analyzed the data using a phenomenological approach because it aligned with the study's intention of examining a group's shared experience with a single concept (Creswell, 2013): middle-school teachers' interactions with problem solving. Thus, the individual experiences were examined and combined as a collective unit to develop a common understanding of this phenomenon (Grbich, 2013).

In analyzing the data, we considered as our unit of analysis single statements or sentences written by the teachers in their journals. In order to address our first research question, we

individually coded these units of data as either "opportunities" or "challenges," depending on whether the teacher indicated that s/he felt empowered or constrained by a particular aspect of the problem or facilitation. However, we quickly understood that this coding scheme was inadequate, as teachers often turned challenges into opportunities. Moreover, even before we prompted them in their reflections to view their experience through a "teacher lens," the participants reflected on multiple pedagogical considerations in addition to their experiences as learners of mathematics. This led us to reorganize the units of analysis into the categorizations of "teacher lens" and "learner lens." Viewing the data in this way aligned with and extended the theoretical framing of professional development proposed by Nipper, et al (2011). The results of this analysis are discussed below.

Preliminary Findings and Discussion

Opportunities and Challenges

The central question of the study aimed to identify the opportunities and challenges that teachers experienced as problem solvers during the professional development workshop centered on problem solving. The results reveal a complex system of relationships between two perspectives—the participant as learner of mathematics and the participant as teacher of mathematics. We will first discuss examples of teachers' opportunities and challenges that we found in the data, followed by a deeper analysis using the adapted framework from a study done by Nipper et al (2011).

Teachers' first-hand experiences as problem solvers revealed a variety of orientations towards problem solving. Teachers' comments fell under two overarching ideas: opportunities that were found to be empowering in some way, and challenges that constrained teachers in some way. A list of the initial themes that emerged within the categories is seen below (Table 2).

Table 2
Teachers' Opportunities and Challenges In Problem Solving Experiences

Opportunities	Challenges
Teachers changing or using multiple strategies to solve the math tasks.	Teachers' confusion and difficulty initiating and solving mathematical problems
The use of teacher collaborative grouping to discuss individuals' problem solving approaches with others.	The use of deficit language in regards to modifying and supporting students
The anticipation and preparation of student responses.	Concerns about time required to solve problems.

In the case of teacher challenges, three central notions emerged. First, teachers' made frequent comments about the difficulty of the tasks and/or failed attempts in finding solutions. Comments regarding the difficulty of problems were found throughout several phases of the problem solving process and included initial reactions to problems, confusion regarding the use of appropriate strategies, and at times, a sense of personal failure when solutions or multiple strategies were not successfully reached. Secondly, teachers' interactions with the problem solving task brought out deficit language regarding students' capabilities, especially when teachers experienced difficulties in solving the problems themselves. For example, participants who had difficulty with the tasks expressed that the problems were "too hard for my kids," "will need to give only one part of the problem," and "will need to use picture and whole class discussion before letting them work on it." We considered comments such as these to be examples of deficit language because the tasks that were chosen for teachers to solve were specific and appropriate for middle-school students. Lastly, there were moments of evident challenge for teachers related to the amount of time required to complete the tasks. Occurrences included teachers' statements about running out of time to reach solutions as well teachers' perceptions that the problem solving process took too much time.

On the other hand, teachers' comments about their problem solving experiences revealed a wide range of opportunities considered to be empowering to their development as mathematical thinkers and as teachers of mathematics. In multiple cases, participants discovered opportunities when moving away from their initial use of an algorithm and/or algebraic formula toward other strategies that were more appropriate for solving the problem. An example is seen with a participant, Christa, who expressed her approach with a task about rates.

> "I first began setting up rates or equations and tried to solve numerically. As I continued I tried to incorporate symbols and finally was forced to use pictures because the problem needed a new strategy. It forced me to think differently."

Moreover, while problem solving in small groups, the data revealed that teachers were exposed to strategies and teaching approaches they had not thought about from their peers. The experience of sharing and solving problems together was a powerful and positive opportunity for participants as learners of mathematics. Group work and discussions supported teachers' content knowledge about the mathematics embedded in the problems they solved and in the strategies, representations, and solutions involved. Additionally, some teachers expressed that they felt empowered and validated when solving problems collaboratively, and having discussions throughout the process helped clarify a variety of aspects about the problems themselves and the approaches they and their peers took. Teachers' comments also revealed that interacting with others led to insights about instructional approaches they could utilize as teachers. These included using the grouping structures and processes they had experienced in the summer program, utilizing manipulatives, and considering the encouragement of multiple strategies and mathematical representations in their classrooms. Comments regarding group discussions after the problems were completed also depicted positive experiences for teachers. Mainly, we noticed that teachers' experience of solving the problems and then reflecting on the process through

journal writing allowed them to think of, prepare, and respond to possible teaching situations with their own students. As one participant expressed, “As a teacher I though the problem was refreshing yet challenging and one that would allow students to argue their solutions productively.” This example showed one of various instances where teachers projected student situations, and had an opportunity to anticipate for instruction when implementing the task in their classroom.

Participants’ Experiences as Both Learners and Teachers

In approaching the second research question, the data revealed that teachers’ immersion with the problem solving process, their engagement in open-ended tasks, and their participation in reflective discussion revealed various aspects about participants’ beliefs and attitudes throughout moments that posed opportunities and challenges.

While we originally grouped the codes under the umbrella topics of "opportunities" and "challenges", many of these experiences began as challenges but led to opportunities. In fact, the themes that emerged from the journal data showed that teachers vacillated between two influential perspectives: a "teacher" lens and a "learner" lens. Within these two lenses, certain main themes arose. Predominantly in the "learner" lens were the participants' experiences with 1L) dealing with confusion or frustration, 2L) running out of time, 3L) working as problem solvers, and 4L) engaging in cooperative learning. When operating under the "teacher" lens, participants were often concerned with 1T) modifying the given problem, 2T) changing the instructional environment provided in order to better solve the problem, and 3T) anticipating student strategies for solutions.

Our data fit nicely into the "instructional rhombus" proposed by Nipper, et al (2011), but the experiences of our participants led us to consider refining this framework. Along with

conceptualizing each "triangle" in the rhombus as the "learner lens" and the "teacher lens", we saw evidence in the teachers' journals of the learner lens influencing and informing the teacher lens for many participants (Figure 1). That is, although the participants where immersed in experiences as learners, they adapted their perspectives as teachers as well.

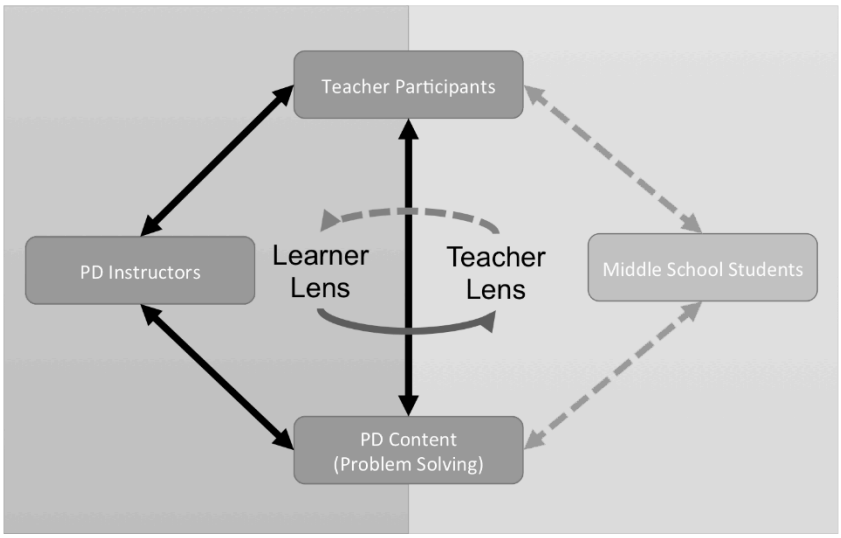

Figure 1: An illustration of the framework proposed by Nipper et al (2011)

The following examples from the data reveal the relationship between the learner and teacher perspective seen through the participants' experiences as depicted in their journals. Some of the teachers who experienced confusion and difficulty starting a problem but gained insight from consulting with their peers also cited the opportunity to work cooperatively as a positive feature of problem solving and one they would reinforce as teachers. One participant, Ulrica, described moments of frustration and lack of confidence while approaching difficult problems. Despite these challenges, she found the overall experience to be valuable to her as a learner and teacher of problem solving. In her final reflection, she stated: "[My experience] has made me aware of some of the struggles my students have with problem solving. I struggled as well during

the training with the process. I was so thankful to my peers (teachers) for helping me through the process. It was a safe environment to be wrong and to learn." She continued by stating her intention to use problem-solving activities with her students on a regular basis. Ulrica utilized here experience of reflecting as a learner and gaining greater empathy for her students to reassess some of her instructional choices.

Kate described her early participation in the group as follows: "I don't think I tried to convince anyone that what I was saying or doing was valid, I just explained what I did and allowed them to critique." However, by the end of the three-week session, her views about the role of discussion seemed to have changed: "Over the last three weeks I was asked to really think about problems differently. I liked that a group of teachers who usually know the answers to questions were actually working on solving problems. I found that I thought I knew the answers, but after really thinking about it, I was required to participate in more conversations with my peers and really listen." This is one of several cases that incorporated how group discussions influenced teachers' perspectives regarding problem solving.

Further commentaries reveal the complexity of approaches towards problem solving, including the influence of teachers' knowledge of and beliefs about their students capabilities. Christa's case demonstrates one such perspective when discussing a problem on building algebraic expressions from physical patterns: "My approach for the problem was very simple. I thought as a student would, say just "add five" every time and probably make a table, but it would be a little difficult to come up with an algebraic expression without having an example for algebraic expressions to choose from."

Contrasting teacher perspectives about implementing such problems appeared in our findings, demonstrating that while teachers solved the same problems, their teaching beliefs

differed. For example, one teacher described solving open-ended tasks as transformative to their teaching approach in his final reflection, stating, “The problems affect the way I think about math. As I change the way I think, I change the way I teach.” He also asserted in a daily reflection on a specific problem that “engagement is a goal, I think students would “get into [the problem].” However, another teacher held a different view regarding the same problem, saying she was “not sure if I would give it to my 6th graders, but we could work towards it at the end of the year.”

Another participant, Linda, revealed through her journal reflections conflicting learner and teacher perspectives about problem solving.

> "Over the last 3 weeks I have become a better problem solver. I have learned to use and try different strategies to solve problems. I would like to try to have my students problem solve more in the class. However, because of time, I think some of the questions would take too long for students to solve. My goal is to try some of the problems out in class and adjust as needed."

In this case, Linda used her experiences as a learner to support her perceptions of implementing problem solving in her class. However, she also used her teaching lens to reflect on possible instructional obstacles she felt could hinder the problem solving experience for her students and further more, thought about preparing for them.

Conclusion and Next Steps

One can see in the reflections that even as teachers were immersed in experiences as learners, they did not abandon their “teaching lens.” The data presented in this paper demonstrated how the two perspectives, we suggest, overlapped and supported the participant’s understandings of their experiences during the problem solving sessions. This study has the potential to expand our knowledge of how teachers interact with problem solving in order to better support their facilitation of open-ended mathematics tasks in the classroom. However the

examples depicted in this paper reveal a portion of the findings and only those that emerged from the participants' written responses. Therefore, our next steps include analyzing the data collected from the participants' own classrooms, which leads us to hypothesize that in addition to participants' learning lenses influencing their teaching lenses, their teaching lenses may possibly inform their learner lenses in turn.

References

Borko, H., Davinroy, K. H., Bliem, C. L., & Cumbo, K. B. (2000). Exploring and supporting teacher change: Two third-grade teachers' experiences in a mathematics and literacy staff development project. *The Elementary School Journal*, *100*(4), 273–306.

Brahier, D. J., & Schaffner, M. (2004). The effects of a study-group process on the implementation of reform in mathematics education. *School Science and Mathematics*, *104*(4), 170.

Buschman, L. (2004). Teaching problem solving in mathematics. *Teaching Children Mathematics*, *10*(6), 302–309.

Common Core State Standards Initiative. (2010). Common Core State Standards for Mathematics. Washington, DC: National Governors Association Center for Best Practices and the Council of Chief State School Officers.

Creswell, J. W. (2012). *Qualitative inquiry and research design: Choosing among five approaches*. Sage.

Crespo, S., & Featherstone, H. (2006). Teacher learning in mathematics teacher groups: One math problem at a time. *AMTE Monograph, 3. The work of mathematics teacher educators*, 97-115.

Edens, K. M. (2000). Preparing problem solvers for the 21st century through problem-based learning. *College Teaching*, *48*(2), 55–60.

Grbich, C. (2012). *Qualitative data analysis: An introduction*. Sage.

Kersaint, G., & Chappell, M. F. (2001). Helping teachers promote problem solving with young at-risk children. *Early Childhood Education Journal*, *29*(1), 57–63.

McCulloch, A. W., Marshall, P. L., DeCuir-Gunby, J. T., & Caldwell, T. S. (2013). Math autobiographies: A window into teachers' identities as mathematics learners. *School Science and Mathematics*, *113*(8), 380–389.

Nipper, K., Ricks, T., Kilpatrick, J., Mayhew, L., Thomas, S., Kwon, N., Klerlein, J.T., & Hembree, D. (2011). Teacher tensions: expectations in a professional development institute. *Journal of Mathematics Teacher Education*, 14(5), 375-392.

Sakshaug, L. E., & Wohlhuter, K. A. (2010). Journey toward teaching mathematics through problem solving. *School Science and Mathematics*, *110*(8), 397–409.

Smith, M. S. (2000). Balancing old and new: An experienced middle school teacher's learning in the context of mathematics instructional reform. *The Elementary School Journal*, *100*(4), 351–375.

Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning*, *10*(4), 313-340.