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Using the Problem-Solving Cycle Model of Professional Development to Support Novice Mathematics Instructional Leaders[i]

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This chapter is focused on the ways our research team supported newly designated mathematics instructional leaders (ILs) to conduct the Problem-Solving Cycle (PSC) model of professional development with teachers in their schools. We describe the challenges of helping a district implement site-based mathematics professional development and ways in which our research team worked with the ILs to help them understand and employ components of the PSC model. We document the lessons our research group learned from this experience, including general lessons about working with novice ILs and lessons specific to the PSC model.

Recently there has been a strong push at the federal, state, and district levels for widely expanded professional development (PD) opportunities for teachers. For example, the No Child Left Behind Act (U. S. Congress, 2001) requires that states ensure the availability of "high-quality" PD for all U.S. teachers. One increasingly common approach to address this requirement is to identify instructional leaders (ILs) at school sites who can provide such support for their colleagues. Districts and schools across the United States are hiring ILs (also called specialists, coaches, or mentors) to work with teachers. As PD providers, ILs typically employ an informal and loosely defined protocol for their work with teachers, such as demonstration lessons, co-teaching, and peer coaching (Portin, Alejano, Knapp, & Marzolf, 2006). This type of in-house approach is intended to provide sustainable professional development for teachers on a large scale.

Well-prepared PD providers are critical to ensure the effectiveness of PD programs. Recent data from a large-scale investigation of 88 PD programs (in mathematics, science, and technology education) as part of NSF's Local Systemic Change Through Teacher Enhancement Initiative suggests that the quality of PD programs is strongly related to the skills, background knowledge, and preparation of the PD providers (Banilower, Boyd, Pasley, & Weiss, 2006). Specifically, in the field of mathematics education, there is mounting evidence that on-going support and structured learning opportunities for ILs can lead to substantial gains in students' mathematics achievement (e.g., Knapp et al., 2003). For example, Middleton and his colleagues worked with a group of mathematics ILs who were released from their classroom duties 50% of the time to engage in and lead PD programs. Fostering and supporting these "local experts" over time led to sustained improvement in mathematics achievement (Middleton & Coleman, 2005).

Although cultivating the knowledge base, experience, and leadership skills of PD providers is essential, it is often a missing step in educational reform efforts (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). As Ball and Cohen (1999) noted, "while the role of the teacher educator is critical to any effort to change the landscape of professional development, it is a role for which few people have any preparation…there is little professional development for professional developers" (p. 28). Zaslavsky and Leikin (2004) similarly argued that a central objective of mathematics PD should be to "interweave the professional growth of mathematics teachers with the growth of mathematics teacher educators" (p. 11).

In this chapter, we describe how our research group formed a partnership with a metropolitan school district and used the Problem-Solving Cycle (PSC) model of mathematics PD (Jacobs et al., 2007; Koellner et al., 2007) to support their newly designated mathematics ILs. We describe the challenges of helping a district implement site-based mathematics PD and ways in which our research team worked with the ILs to help them understand and employ components of the PSC model. We document the lessons our research group learned from this experience, including general lessons about working with novice ILs and lessons specific to the PSC model. By the end of the school year, the ILs reported that, in addition to familiarizing them with the PSC model of PD, our meetings had a substantial impact on their self-perceptions as ILs and on their interest in implementing the PSC in their schools.

Conceptual Framework for the Problem-Solving Cycle Model

Situative perspectives on cognition and learning provide the conceptual framework that guided the design of the PSC model. Scholars within a situative perspective argue that knowing and learning are constructed through participation in the discourse and practices of a community, and are shaped by the physical and social contexts in which they occur (Greeno, 2003; Lave & Wenger, 1991). With respect to PD, situative theorists focus on the importance of creating opportunities for teachers to work together on improving their practice as well as locating these learning opportunities in the everyday practice of teaching (Ball & Cohen, 1999; Putnam & Borko, 2000). We share with many teacher educators the view that constructivist and situative theories are interrelated and that learning involves both construction and enculturation (Cobb, 1994; Driver, Asoko, Leach, Mortimer, & Scott, 1994). Three design principles derived from this framework are central to the PSC model: 1) Establishing a professional learning community; 2) Using video from teachers' own classrooms to provide a meaningful context for learning; and 3) Establishing community around video.

The Problem-Solving Cycle Model

The PSC model of mathematics PD is an iterative, long-term approach to supporting teachers' learning. One iteration of the PSC is a series of three interconnected PD workshops in which teachers share a common mathematical and pedagogical experience, organized around a rich mathematical task. This common experience provides a structure upon which the teachers can build a supportive community that encourages reflection on mathematical understandings, student thinking, and instructional practices. The PSC model is designed to be implemented by a knowledgeable facilitator, who carefully plans and implements each workshop and continually monitors the participating teachers' needs and interests.

During Workshop 1, the facilitator introduces a rich task selected on the basis of the teachers' needs and interests. Teachers collaboratively solve the task, debrief their solution strategies, and develop plans for teaching it to their own students. Teachers share ideas about solving and teaching the PSC problem and create lesson plans tailored to the specific class(es) in which they will teach it. The main goal of this workshop is to help teachers develop the content knowledge necessary for planning and implementing the PSC problem. After Workshop 1, each participant teaches the PSC problem in one of his or her mathematics classes, and the lesson is videotaped.

The facilitator designs two subsequent workshops to focus on the teachers' experiences using the problem in their classrooms, relying heavily on video clips and written student work from their lessons. The major analytical focus of Workshop 2 is the role played by the teacher in implementing the problem. The facilitator selects video clips that can serve as a springboard for exploring topics such as how the teachers introduced the task and managed the classroom discourse. Activities in Workshop 3 are centered on a critical examination of students' mathematical reasoning. Facilitators select video clips and examples of students' written work on the PSC problem, and support discussions around topics such as unexpected methods students used to solve the problem and the ways students explained and justified their ideas.

Initial Research on the Problem-Solving Cycle

Our research team developed the PSC as part of a research and PD program that began in 2003. In the first stage of the program we worked with a group of middle school mathematics teachers to develop and refine the model. In fall 2003, we conducted a series of PD meetings that focused on fostering mathematical content and pedagogical content knowledge, developing norms for viewing and analyzing classroom video, and promoting a community of learners. We conducted the first PSC in spring 2004 and two more iterations during the 2004–2005 academic year. The three iterations used different mathematics problems and focused on different aspects of the teacher's role and students' mathematical reasoning (see Borko, Jacobs, Eiteljorg, & Pittman, 2008 for more details). We utilized a design experiment approach (Design-Based Research Collective, 2003) to study, document, and refine the model. In addition, we created a Facilitator's Guide[ii] to help professional development facilitators learn about the PSC and prepare to implement it with teachers.

Scaling Up: Preparing Instructional Leaders to Facilitate the PSC

The next stage in our research program involved "scaling up" the PSC model by introducing it to a group of middle school mathematics instructional leaders in the Aria school district[iii]. Our research goals were to document the processes involved in preparing ILs to implement the PSC, and to further refine the facilitation materials. We began working with Aria in Fall 2006, the first year they had designated a mathematics teacher in each of their 11 middle schools to be an instructional leader. Aria's interest in developing the leadership skills of their ILs as facilitators of school-based mathematics professional development appeared to overlap neatly with our agenda of preparing and supporting PSC facilitators.

The ILs in Aria were selected by their principals and given responsibility for widely varying roles, including holding monthly "early-release day" (ERD) meetings with the other mathematics teachers in their schools, purchasing textbooks, and in some cases analyzing student assessment data. The district also had a full-time mathematics coordinator, Becki, whose multiple roles included helping teachers learn about and navigate a newly adopted textbook series, *Connected Mathematics Project 2*[iv] (CMP2) (Lappan, Fey, Fitzgerald, Friel, & Phillips, 2006a), creating district-wide mathematics assessments, and supporting the mathematics ILs.

Throughout the 2006-2007 school year, Becki led monthly, full-day PD meetings that the district required all middle school mathematics ILs to attend. As part of the collaboration with our research team, Becki sought volunteers from this group to attend additional full-day PSC meetings with our team; four instructional leaders and their principals agreed. Aria's objective was for Becki and the four ILs to take what they learned from our PSC meetings back to the other ILs in the district (during the district IL meetings) as well as to the teachers in their schools (during the ERD meetings).

PSC Meetings with Aria's Instructional Leaders

We held five, full-day PSC meetings with Aria's mathematics coordinator and four middle school mathematics ILs during the 2006-2007 school year. These meetings were conducted by two members of our research team. At each meeting, at least one other member was present to videotape the session and participate as appropriate. Drawing from our field notes and videotaped records, we briefly describe these meetings, including our goals for the meeting, the major events that took place, and the lessons our research team learned as the meetings unfolded.

PSC Meeting 1: Overview of the PSC Model and Selecting a Task

Meeting goals and activities. The goal for our initial meeting was to introduce the PSC model. To this end, we shared a detailed PowerPoint presentation, providing an overview of the PSC model and examples of our research team's prior experiences working with middle school mathematics teachers using the model. Selecting a rich mathematical task is the first component in implementing the PSC model, and one of the most critical decisions for facilitators. We brought two possible tasks to the meeting and asked the ILs to examine each task and select one to use. After an extended discussion about which task would be most appropriate for their students and teachers, the group decided on the Pool Border problem (Lappan, Fey, Fitzgerald, Friel, & Phillips, 2006b), explaining that it better matched the mathematics content and processes addressed in the CMP2 middle school curriculum.

Lessons learned. Becki came to the first meeting optimistic and enthusiastic about the partnership with our research team, counting on us to help motivate and support the instructional leaders. However, although all of the instructional leaders had chosen to take part in the program in order to foster their leadership skills, they came to the meeting with virtually no information about the nature of our proposed PD agenda. At the beginning of the meeting, the group talked at length about the current state of mathematics PD in Aria. The ILs explained that not only did they have limited experience with and understanding of their role, they were especially concerned about having to implement an unfamiliar PD model with the teachers in their schools, and they did not know how they would manage the time constraints and sometimes competing priorities felt at the school and district levels.

Our research team responded to these concerns by explaining that the PSC model is flexible and extremely responsive to participants' specific and changing needs, particularly with respect to mathematics knowledge, pedagogical practices, community development, and available time for PD. Despite this response, the ILs remained cautious about committing to use the PSC model with the other teachers in their buildings. Over the course of the year, we came to understand more clearly that newly designated ILs may not be ready to dive into any specific PD model at the beginning of their tenure. In addition, as we learned more about each participant's individual circumstances and needs, we gained a better sense of how to support and encourage them to take an active role as an IL and as a facilitator of the PSC.

PSC Meeting 2: Debriefing the School-Site Meeting and Discussing Video

Meeting goals and activities. Our goal for the second meeting was to address the next several phases of the PSC model, after facilitators have selected (and solved) the PSC task. These phases include developing individual lesson plans to implement the selected task, considering logistics associated with videotaping teachers, fostering a community that is comfortable being videotaped and watching video of themselves, and selecting clips from videotaped lessons as a springboard for focused discussions. Shortly after the first PSC meeting, Becki held a district wide IL meeting during which they worked on and discussed the Pool Border task. In addition, Becki had encouraged the ILs to use the task in their classrooms. Two of the ILs from our group had done so; one videotaped her own lesson and the other collected student work samples. Therefore, although we had anticipated spending a large chunk of our second PSC meeting time working with the ILs to develop detailed lesson plans for the Pool Border task, it seemed more prudent to examine and discuss these artifacts. We also talked about videotaping logistics, fostering community around video, and selecting video clips.

Lessons learned. From this meeting, we realized the extent to which activities that take place between PSC meetings can directly impact our intended agenda. It was critical to allow time at the beginning of each PSC meeting to gather information about relevant PD activities at the district and school level that took place following the previous meeting. We also became aware of the importance of communicating with the participants before meetings to learn about interim activities that might influence the nature of the meetings.

PSC Meeting 3: Introducing the Snakes in Snakewood Problem (Roodhardt, Kindt, Burrill, & Spence, 1997)

Meeting goals and activities. For the third meeting we brought a new mathematics task in order to support the ILs' emerging understanding of the student thinking component of the PSC model. In particular, we wanted the ILs to examine the role of video in fostering extended conversations about student reasoning related to the PSC task. The task we brought to the meeting, the Snakes in Snakewood Problem, was one that our research team had used in our initial development of the PSC model; thus, we had video of middle school lessons that we could view with the ILs. The group worked on and discussed the problem and then watched a video clip showing students solving the same problem. The ILs considered aspects of algebraic reasoning, such as various ways the students generalized their patterns, and they talked about discussion questions they could use if they were to facilitate the viewing of this clip.

Lessons learned. One lesson we learned at this stage of our PD work with Aria's ILs was that participation in the PSC as teacher-learners is a critical component in preparing for the facilitation role. We now hypothesize that it takes at least one iteration of experiencing the PSC *as learners* for ILs to grasp the overall structure of the model, and to see firsthand how the different components work together to support teacher learning. After they took part in one (adapted) iteration of the PSC, largely in their role as classroom teachers, the ILs were much more enthusiastic about the model, confident in their ability to facilitate the workshops, and interested in implementing it with teachers in their buildings.

PSC Meetings 4 & 5: Considering the PSC Components from a Facilitator's Perspective

Meeting goals and activities. Our goals for the fourth and fifth meetings were for the ILs to consider the following components of the PSC model from a facilitator's perspective: understanding the characteristics of an appropriate PSC mathematics task; using video to explore the teacher's role in a PSC lesson; and choosing video clips and developing focused discussion questions. In the fourth meeting, we brought a selection of three mathematics tasks for the ILs to solve. We then discussed whether and why each of these tasks would be appropriate for the PSC, and we listed important characteristics of PSC tasks, such as having multiple entry/exit points, eliciting different solution strategies, and the likelihood of fostering mathematically productive discourse. Lastly, the ILs watched a video clip of a middle school teacher implementing the Snakewood problem and considered how they might use such a clip with their own teachers.

In the fifth meeting, we focused on selecting video clips and developing questions to elicit discussion. Unlike prior meetings, where we had pre-selected clips for the ILs to examine, during this meeting the ILs picked out short video clips from a forty-minute excerpt of a teacher's Snakes in Snakewood lesson. They worked in two groups; one group focused on the teacher's role and the other focused on student thinking. Each group watched the video, selected one or more short clips, and developed questions to elicit discussion to match their focus (teacher role or student thinking). The groups then shared their selections, described why they choose the clips, and responded to one another's discussion questions.

Steps forward. During these final two PSC meetings, the ILs talked at length about their increasing comfort with the PSC model and their growing enthusiasm for taking an active role as facilitators of the model. They spoke of their intention to use the overall structure of the model to lead PD efforts with the mathematics teachers in their building during the following school year. Moreover, they appeared determined to take advantage of district- and school-mandated PD time for the 2007-2008 school year to put what they learned as PD providers into practice.

Overall Impacts of the Program on the Instructional Leaders

During our final PSC meeting we conducted individual face-to-face interviews with the ILs, asking them to consider the impact of the PD program on their learning as both teachers and instructional leaders. These interviews were audio-recorded and transcribed. Our research team systematically examined the transcripts, as well as videotaped conversations with the ILs during meetings four and five, in order to document the ILs' impressions of the PD program's major areas of impact.

Consistent with the literature showing that the role of the professional developer is often ill-defined (Portin et al., 2006), the Aria ILs began the PSC meetings with little understanding about the expectations of the district and their schools for sustained mathematics PD and the role they would play in that regard. As one IL, Trina, commented, "I think we came in not knowing what we were doing at all." By the end of the year they had a much clearer understanding of how the PSC could be adapted for use as a PD model with the teachers in their buildings, and they began to take ownership of the process. For example, they told us of their intention to use the mathematics PD time allocated by their administration to implement the PSC during the 2007-08 school year.

The ILs were particularly enthusiastic about working collaboratively with other mathematics teachers to solve rich problems and share solutions. In addition, by deeply analyzing student thinking during the meetings, they gained a strong appreciation of the ways students at different grade levels can engage in the same rich mathematics task. As Lisa explained, "It's really nice to see how other people solve problems because that helps you see how kids are solving problems in different ways too." Janice told us,

> The thing that I took away from this experience in terms of my role as a math teacher was the math problems. Not just doing the problems with the kids, but reflecting on the way that I actually teach them...because as we got back together, and we talked about it and the way different people taught it and that type of thing, it makes you reflect inwardly as a teacher.

The ILs became very interested in videotaping themselves and other teachers implementing PSC tasks in their classrooms. They talked about how powerful it was to watch video clips from PSC lessons and examine the teacher's role and student thinking. Millie noted,

> What stands out [about the PSC meetings] is the value of videotape - watching videotape and being videotaped. The willingness to be videotaped is critical for your own development as well. It gives you a chance to evaluate how you are as a teacher, or how you respond back to kids.

With respect to facilitating the PSC with other teachers in their buildings, she added, "You have convinced me that [videotaping] is powerful. Now I have some ways to show teachers that are powerful also."

Like the ILs, our research team learned valuable lessons from each meeting – lessons that enhanced our thinking about the PSC and steadily improved our delivery of the PD program. Our willingness to take Aria's district, school, and individual ILs' needs into account demonstrated the flexibility of the PSC model and had a very positive impact on the ILs. This impact was noted, for example, by Becki, who reflected, "You looked at all of the nitty-gritty components of what goes on within a specific school district that would prohibit the level of growth and then you adapted. This showed the teachers that you valued them." Several conversations in the final two workshops centered around the importance of valuing the ILs' input regarding specific PD activities and time structures, and tailoring the program to their unique needs. Millie commented,

> Your willingness to find out what our needs were has opened up a lot of doors for us to go back now and work with our individual schools. Because at first when we started this program, it was like, there is no way [this can happen].

Janice added,

> You guys really listen to us. And you brought us your ideas. But, yet, you molded them to something that we could really use....We always talk about [this experience], going back, as the best opportunity we've had for professional development, where somebody listened to our needs.

Implications for the Field of Mathematics Professional Development

The insights we gained through our experiences using the PSC model to support Aria's novice ILs in their pursuit of learning about and providing site-based mathematics PD add to the emerging literature on the professional development of professional developers. We learned, for example, that it was important for the instructional leaders to experience the PSC model as learners before attempting to implement it as facilitators. It also became clear that establishing a professional learning community and tailoring the PSC model to the Aria context were critical aspects of the success of our work with the ILs. In combination, these design features helped to build the leadership capacity of the novice PD facilitators, and we conjecture that they are essential for the successful "scale-up" of the PSC professional development model. We also hypothesize that they are relevant to the preparation of facilitators for other models of professional development.

We believe that these conjectures regarding the leadership capacity of professional development providers warrant further research. We also encourage researchers in the field to consider developing tools to measure changes in leadership capacity, in order to foster more quantitative investigations. Constructs, such as professional knowledge, professional identity, and community-building skills, will undoubtedly come into play and need to be considered in a more deliberate fashion. Building the body of literature in the emerging field of professional development for PD providers is a critical step in the complex arena of promoting student learning.

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[ii] A draft of the Facilitator's Guide to Planning and Conducting the Problem-Solving Cycle is available on our website:

http://www.colorado.edu/education/staar/

[iii] The name of the school district and all school and district personnel mentioned in this chapter are pseudonyms.

[iv] For more information on CMP2, see their website:
http://www.phschool.com/cmp2/

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