

Interventions Involving STEM Professional Learning Communities

Excerpted from Carlson, M., Bowling, S., Moore, K., & Ortiz, A. (2007). The role of the facilitator in promoting meaningful discourse among professional learning communities of secondary mathematics and science teachers. In T. Lamberg & L.R.Wiest (Eds.), *Proceedings of the 29th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 841-848). Stateline (Lake Tahoe), NV: University of Nevada, Reno.

This study investigated the mathematical discourse among members of four different professional learning communities (PLCs) of secondary mathematics teachers. In this report, we focus on PLC facilitators roles in promoting meaningful mathematical discourse among the learning communities' participants. By "meaningful mathematical discourse" we mean substantive conversations about understanding, learning, and teaching mathematics. We took a design research approach in which a strategy to support the PLC facilitators was continually refined as we investigated its impact on the quality of the PLC mathematical discourse. Our findings revealed that facilitators who made efforts to understand the thinking and perspectives of other PLC members (we call this *decentering*) were better able to engage the members of the community in meaningful discourse. This paper describes five manifestations of decentering and their effect on the mathematical discourse among the PLC's teachers. It also illustrates the ways in which four PLC facilitators, over time, decentered, some with increasing flexibility and increasing effect on the PLC's discourse. Findings also revealed that a facilitator's level of understanding of the concept that was central to the lesson influenced the quality of the PLC discourse. This was revealed in his/her questions, choice of tasks, and discussions with members of the PLC.

Excerpted from Clark, P., Moore, K., & Carlson, M. (2008). Documenting the emergence of “speaking with meaning” as a sociomathematical norm in professional learning community discourse. *The Journal of Mathematical Behavior*, 27, 297-310.

Project Pathways is a 5-year project in which STEM scientists and educational researchers are partnering with four secondary school districts to produce a research-based and tested model for enhancing instruction of mathematics and science in grades 9–12. This Math and Science Partnership (MSP) is investigating the effectiveness of a four course graduate sequence with accompanying professional learning communities. In partnership with school leaders, university faculty developed four mathematics/science graduate courses, all of which had a focus on modeling and a connecting theme of covariation, i.e., models emerged from attending to the variation of two quantities as they changed in tandem. The university faculty intended these courses to support secondary mathematics teachers in developing knowledge of foundational concepts of introductory math, science and engineering courses at the university level. The secondary mathematics and science teachers that are the focus of the MSP study attended the course one night per week and met for 1 h each week in PLCs. The primary purpose of the PLC meetings was to support teachers in engaging in meaningful discussions about issues of learning and teaching concepts that were central to the course. The courses and accompanying 1-h PLC meetings were held at school sites. The data for this study was collected in the first of the four-course sequence and during the accompanying PLC meetings.

A university faculty member instructed the graduate course and made explicit efforts to promote meaningful discourse in the class by assuring that individual teachers *spoke with meaning* when communicating to the class and during small group discussions. On the first day of class the instructor led a discussion about the role of communication in learning and using mathematics concepts to solve problems. This discussion led to the negotiation of specific goals for communication during the class and in the PLC sessions. The instructor prompted the teachers to describe how they could individually contribute to a classroom culture in which the communication was meaningful. The teachers volunteered responses indicating that they would need to: (i) listen to and attempt to make sense of the meanings conveyed by the teacher and their colleagues; (ii) attempt to communicate meanings when they spoke; (iii) respect the learning process of the individual; and (iv) ask for clarification if someone else’s meanings are not clear. The class decided to call these explicit communication goals “Rules of Engagement.” The explicit negotiation of these goals appeared to contribute to most teachers valuing them as something worthy of striving for when communicating during the class and PLC sessions.

During the first class session the instructor posed mathematical questions, consistently listened to the meanings conveyed by the teachers, and made specific prompts to support the teachers in *speaking with meaning* when providing their responses. The instructor also attempted to model *speaking with meaning* whenever she spoke. Throughout the course the instructor frequently prompted the teachers to provide a rationale for a solution approach. She also made regular prompts for the teachers to reference the quantities and relationships in a problem context. She further encouraged them to avoid use of pronouns when describing a solution (e.g., instead of saying “it is growing,” say, “the amount of money in the account is increasing as the number of years since 2000 increases). Also, in an effort to be explicit about the type of communication expected, the instructor publicly called attention to instances when a teacher *spoke with meaning*

during the class. This move by the instructor is an example of the use of the phrase “*speaking with meaning*” as a tool that an instructor can use in a classroom.

The PLC facilitators were expected to promote *speaking with meaning* during the PLC sessions. Initial investigations revealed that the facilitators had difficulty modeling and reinforcing these behaviors. It appeared that their mathematical understandings at this stage of the course were too weak to support meaningful communication. They also appeared to have little experience reflecting on or attending to the meaningfulness of their speaking. This led to our developing facilitator workshops designed to support the facilitators in modeling *speaking with meaning* and promoting meaningful communication among members of a PLC. During the workshops the teachers viewed videos of their PLC sessions for the goal of helping the teachers recognize how and when to intervene during discussions to assure that the PLC members were engaged in meaningful communication. The workshop leaders used videos of PLC sessions to illustrate communication patterns that were meaningful and ones that were not meaningful. After showing a particular video clip, the workshop participants were prompted to identify instances when the PLC facilitator promoted *speaking with meaning* and when the facilitator missed opportunities to support *speaking with meaning*. The PLC workshop leader also held a 30-min coaching session with the PLC facilitators after each class session.

Excerpted from Kettlewell, J. (2008). *Partnership for reform in science and mathematics* (Interim report No. 03147953). Georgia: University System of Georgia.

PRISM professional learning communities bring K-12 teachers and higher education faculty together to share expertise and experience as they develop, validate, and replicate effective practices in science and mathematics teaching. Several viable and successful yet distinct implementation models have been created under the umbrella of the PRISM K-16 Learning Community definition. These range from school-based professional learning communities to statewide communities of practice. Throughout the implementation of PRISM Phase I, several characteristics were observed to be common to most PRISM LCs, regardless of the model type, be it school based, district based, grade level focused or vertically aligned. These characteristics included support of an overarching partnership such as PRISM, facilitative and shared leadership, shared practice, a focus on teaching and learning, and use of evidence to both give direction to the learning community and assess its effectiveness. These characteristics are reflective of the attributes of K-12 LCs as reported in the literature. Yet, the differences in roles of IHE faculty in learning communities varied widely among PRISM K-16 LCs and the following questions persisted: What are the attributes of successful K-16 LCs, how do these attributes interplay with the role of higher education faculty in the LC? and, how do each of these things correlate to the impact of the PLC on teaching and learning, and on professional practices?

Some of these questions about K-16 learning communities were partially answered through the PRISM Phase I evaluation. Indeed, reports from participants, PRISM leaders, and the PRISM evaluation team examined whether being a member of a K-16 learning community had a variety of positive effects, including changes in teaching practices, development of new partnerships, enhanced content understanding, greater appreciation for the work of K-12 teachers, and improvement in student learning. The purpose of Research on Learning Communities in PRISM Phase II is to 1) firmly identify the attributes of successful K-16 learning communities and develop an instrument package to effectively measure them, and 2) to systematically examine the relationships between these attributes and three specific K-12 outcomes: a) classroom teaching practices; b) student learning; and c) teacher professional behavior.

Excerpted from Monsaas, J. (2006, October). *Engaging Higher Education Faculty in K-16 Learning Communities to Improve Teaching and Learning in Science and Mathematics in the K-12 Schools*. Paper presented at the Math and Science Partnership Evaluation Summit II, Minneapolis, MN.

The Partnership for Reform in Science and Mathematics (PRISM) is a comprehensive MSP project with state and regional partners. The state partners include the University System of Georgia, the public higher education state agency, and the Georgia Department of Education, the K-12 state agency. Four regional P-16 partnerships include at least one institution of higher education (IHE) and one K-12 system. The IHEs include major research universities, regional universities, state universities and two-year college partners. The K-12 systems range from large urban to small rural districts.

A major goal of PRISM is to increase the quality of science and mathematics teaching in Georgia. One strategy is to implement school, district and cross-district level Learning Communities (LCs). These PRISM LCs may focus on mathematics, science or both, but the goal is to have at least one IHE science or mathematics faculty member working with each PRISM LC.

This paper reports findings from the quantitative evaluation of PRISM. This paper addresses the following questions:

- Does participation in a LC increase K-12 teachers' use of inquiry- and standards-based teaching practices in science and/or mathematics (SM) classes?
- Does having IHE faculty members engaged in LCs increase K-12 teachers' use of inquiry- and standards-based teaching practices in SM classes?

While PRISM learning communities are unique in each school, district and PRISM region, there is an underlying structure on which each is designed. The PRISM Leadership Team generated a definition document for learning communities that includes the essential characteristics that provide the underpinnings of each PRISM learning community:

- Trying, testing, verifying, and replicating teaching practices deemed to have a positive impact on K-16 student learning
- Shared vision of teaching and learning among K-16 faculty participants
- Collaboration between K-12 and higher education faculty
- Shared leadership by K-16 faculty participants
- Making the work of learning community participants public
- Results oriented work
- Collaborative inquiry

During the 2005-06 year, there were over 200 PRISM⁴ LCs in the four regions of the state. Many, but not all, had one or more IHE faculty members working with them. Some regions had challenges getting enough IHE faculty to work with all their LCs. This allows us to analyze the difference in teaching and learning practices for teachers in LCs that do and do not have an IHE member.

Excerpted from Murray, K., Henry, M., & Hoglebe, M. (2009). The impact of early positive results on a mathematics and science partnership: The experience of the Institute for Chemistry Literacy Through Computational Science. *The Journal of Mathematics and Science: Collaborative Explorations*, 11, 95-108.

This paper addresses the case of the Institute for Chemistry Literacy through Computational Science (ICLCS), a National Science Foundation Mathematics and Science Partnership (MSP) Institute Project led by the University of Illinois at Urbana-Champaign's (UIUC) National Center for Supercomputing Applications (NCSA), School of Medicine, and Department of Chemistry. The ICLCS is a five-year research project investigating the effects of a statewide teacher professional development effort aimed at rural Illinois high school chemistry teachers. Thom Dunning, a professor in the Department of Chemistry and Director of NCSA, is the project's Principal Investigator. In addition to UIUC, other core partners for the project are the AC-Central School District and the Regional Office of Education #38, both rural educational entities in central Illinois.

The project includes the following goals:

- Improved teacher and student content acquisition in the context of present-day research;
- Increased teacher comfort with and use of computational and visualization tools in the classroom;
- Teacher-leadership development in STEM and computational science education; and,
- Related institutional change at the University and among the K-12 educational partners engaged in the project.

The project, funded in 2006, has just entered its second year of treatment for one cohort of teachers and its first year of treatment for the second cohort. This second cohort also serves as the control group for the first cohort. Treatment includes the following components: an intensive two-week summer institute conducted annually for three years for each cohort; ongoing virtual learning community activities through work group assignments, lesson planning, resource sharing, and rapid-response support to teachers' questions; twice annual workshops; provision of tools and technical support to teachers for use in their classrooms; and, individual leadership development planning. Central to project communications and activities is the use of a centralized, on-line system through which almost all ICLCS contacts, assignments, work products, resource information, etc. are shared. Teachers will be followed for two years after the formal treatment course. This article describes the research design and methods used for the project, reports early results, and discusses some of the effects of these early results on the project, evaluation, and research plans and activities.

Excerpted from Oehrtman, M., Carlson, M., Sutor, J., Agoune, L. & Stroud, C. (March, 2009). *Meaningful collaboration in secondary mathematics and science teacher professional learning communities*. Paper presented at the Proceedings of the Twelfth Conference on Research in Undergraduate Mathematics Education, Raleigh, NC.

Project Pathways is an ongoing Math and Science Partnership at Arizona State University to implement and research teacher professional development in six large urban school districts. One component of Project Pathways has been school-based Professional Learning Communities (PLCs) for interdisciplinary groups of secondary mathematics and science teachers. PLC sessions engage teachers in conceptual conversations about knowing and learning central ideas in secondary mathematics and science, discussion and assessment of student thinking, development of inquiry-based conceptually-focused lessons, and reflection on the effectiveness of their instruction. This paper focuses on results related to the following research questions:

1. What issues motivate teachers to engage productively in a PLC around reflection on teaching practice and implementing change in their classrooms?
2. What supports are necessary for engaging teachers reform efforts derived from various motivating issues?

**Excerpted from Pane, J., Williams, V., Olmsted, W., Yuan, K., & Spindler, K. (2009).
Math science partnership of Southwest Pennsylvania measuring progress towards
goals. RAND Corporation. Santa Monica, CA.**

The MSP brings together 53 K–12 school districts, four IUs, and four IHEs in Southwestern Pennsylvania. Its goals are to increase K–12 students’ knowledge of mathematics and science, increase the quality of the K–16 educator workforce, and create sustainable coordination of partnerships in the IUs. The project began in September 2003 with an initial funding period of five years. In 2008, the NSF extended the end date of the project to 2010. The MSP serves Southwestern Pennsylvania, including the urban fringe of the City of Pittsburgh, several smaller urban areas, suburbs, and rural areas. The school districts in the MSP are relatively small: Total enrollment is approximately 114,000 students, an average of about 2,150 per district. The typical MSP school district has only four or five schools. The MSP districts have a total of approximately 3,400 teachers who teach math or science topics. On average, about 39 percent of students in MSP schools are economically disadvantaged, compared with a statewide average of 36 percent. This figure is higher in the PDE MSP districts (59 percent) than in the NSF MSP districts (35 percent). The enrollment of underrepresented minorities is approximately 19 percent, compared with a statewide average of 22 percent. Again, this figure is higher in the PDE MSP districts (25 percent) than in the NSF MSP districts (18 percent). These demographics vary widely across schools.

The MSP intervention strategies are as follows:

- *Professional development for content and leadership* is accomplished through academies and seminars for K–12 educators and IHE faculty. The overriding purpose of these activities is to equip teachers with the content, pedagogy, and leadership skills necessary to become effective leaders in their institutions.
- *Curriculum alignment and pedagogical and course refinement* are accomplished at the K–12 level through the use of curriculum frameworks and research-based curriculum materials and at the IHE level through the contributions of K–12 teachers who spend one to two semesters or a summer on IHE campuses, working with faculty to refine IHE courses.
- *Support for and dissemination of research-based resources and tools*, which is accomplished primarily through conferences and support networks connecting educators using research based curricula.

Importantly, these intervention strategies are not distinct and separable; rather, they are intertwined in a design that unites K–12 and IHE educators in working to achieve the three primary goals of the MSP.

Excerpted from Sack, J. & Kamau, N. (2009). The impact of the lead teacher professional learning community within the Rice University Mathematics Leadership Institute. *The Journal of Mathematics and Science: Collaborative Explorations*, 11, 141 – 162.

Now in its fourth year, Rice University's Mathematics Leadership Institute (MLI) has developed over sixty high school mathematics Lead Teachers. We focus on how membership in MLI has impacted participant teachers' professional lives. The Lead Teacher community that emerged during MLI's first Summer Leadership Institute embodies the characteristics of a sustaining and coherent *knowledge* community where teachers are able to share their secret "stories of practice in safe places . . . in order to make their personal practical knowledge explicit to themselves and to others". This article includes stories of individual teachers who refused to sacrifice hours of instructional time for mandated curriculum testing, who encouraged and supported a large group of MLI teachers to participate in a grueling advanced certification program, and who challenged the local administration's expectation to compromise personal professional standards. These stories may not have emerged in their particular ways had these teachers and their supporting co-manager not been members of this coherent and sustained knowledge community. This knowledge community has enabled the achievement of MLI goals with respect to teachers' increased mathematics content knowledge, leadership development, and student achievement.

In 2004, the Mathematics Leadership Institute (MLI), a National Science Foundation funded Mathematics and Science Partnership (MSP), was established as a partnership among Rice University and Houston Independent School District (HISD) and Aldine Independent School District (AISD). During its longstanding relationship with these two districts, Rice University advised and collaborated with district-level mathematics directors on district-wide initiatives, and in individual schools and with mathematics teachers of all grade levels.

Each MLI cohort attends two Summer Leadership Institutes, each for a four-week period for two consecutive summers. The focus of these Institutes is to develop teachers' mathematical pedagogical content knowledge, leadership skills to interface with administrators and mentor peers, and to think about school and classroom diversity in new ways, ultimately to increase student achievement in participating schools. The MLI teachers also meet regularly during the academic years over the five-year life of the grant.

Excerpted from Weaver, D. & Dick, T. (2009). Oregon mathematics leadership institute project: Evaluation results on teacher content knowledge, implementation fidelity, and student achievement. *The Journal of Mathematics and Science: Collaborative Explorations*, 11, 57-84.

The Oregon Mathematics Leadership Institute (OMLI) NSF-MSP project partners are Oregon State University, Portland State University, Teachers Development Group and ten Oregon school districts. The primary activities of the project were a sequence of three intensive three-week residential institutes emphasizing mathematics content knowledge for teaching, collegial leadership, and the building of professional learning communities. Teachers at all levels K-12 participated together in the mathematics content courses. By the conclusion of the third summer institute, teachers had shown significant improvements in mathematical content knowledge for teaching. Analysis of student achievement data in participating schools was initially inconclusive. However, once implementation fidelity traits were taken into account, a positive relationship between project participation and student achievement emerged. The degree to which schools implemented the practices promoted by the OMLI project is a significant positive predictor of student performance above and beyond what can be explained by the socioeconomic factor as indicated by the percent of students who qualify for free and reduced lunch program. This relationship is particularly acute at secondary levels, but additional factors appear to be at play at elementary grade levels.

Setting: OMLI is a partnership between Oregon State University, Portland State University, Teachers Development Group, and 10 Oregon school districts: Beaverton, Bend-LaPine, Crook County, Molalla River, North Clackamas, Redmond, Reynolds, Roseburg, South Lane, and Woodburn. These school districts include both rural and urban settings, a wide range of socioeconomic student backgrounds, and one district with a majority of ELL students.

Intervention: The unit of participation in OMLI is a School Leadership Team, ideally consisting of two teachers and one school administrator, usually the principal of the school...Participating teachers attended 3-week residential summer institutes in three consecutive summers (2005, 2006, and 2007). The participating administrators attended the third week of each of the three summer institutes. These summer institutes included mathematics content coursework across six strands: numbers and operations, algebraic structures, measure and change, geometry, data analysis and probability, and discrete mathematics. The mathematics content coursework was complemented by leadership development coursework. Academic year activities facilitate the ongoing development of collaborative professional learning communities within each participating school. These activities will continue at least through the 2008-2009 academic year and are intended to promote and sustain systemic mathematics reform to increase student achievement in mathematics.

Site visits to participating OMLI schools involved a minimum of a half-day site visit per school, with four site visits each year per school. These site visits are designed to:

1. Support School Leadership Teams for implementation of their Collegial Leadership Action plans, which were crafted by the teams during the 2007 Summer Institute to initiate and sustain school-based collaborative professional learning communities whose work centers on mathematics content, learning, teaching, and leadership.

Support continued learning by the OMLI participants and their school colleagues through first-hand experiences with practice-based professional learning facilitated by OMLI faculty. Specific site visit activities designed to support learning for effective lesson design and implementation

School Leadership Teams were expected to actively increase the quantity and quality of school-based collegial inquiry and discourse about mathematical and pedagogical content by planning and facilitating regular academic year meetings of building colleagues, using and facilitating practice-based professional development activities such as classroom observations and collaborative examinations of student work.

Research Questions:

1. Has the OMLI professional development prepared the teacher leaders for their leadership role in terms of mathematics content knowledge for teaching?
2. Has the OMLI project increased student achievement (as indicated by the percentage of students who demonstrate proficiency on the Oregon State Mathematics Assessment for grades 3, 5, 8, and 10) in all participating K-12 schools?