

**Session Number: 36**

Abstract Name: **Coherence and Change in Teacher Professional Learning Communities**  
MSP Project: Project Pathways: Opening Routes to Math & Science Success for All Students  
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### **1. Questions(s) or issue(s) for dialogue at Learning Network Conference session:**

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 presentation 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?

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### **2. Context of the work within the STEM education literature and within your MSP project:**

Project Pathways was originally grounded in three discipline-specific frameworks for engaging in the processes of mathematics, science, and engineering. Carlson and Bloom (2005) developed a *multidimensional mathematical problem-solving framework* through empirical studies of the cognitive and meta-cognitive processes of research mathematicians. The mathematicians' problem-solving behaviors were cyclical in nature, consisting of four primary phases. They first oriented themselves to the nature, elements, and structure of the problem. They then conjectured solution paths, rapidly evaluating the potential effectiveness and requirements of each before making a decision on how to proceed. Once they began executing their chosen plan, they monitored their progress and the viability of the emerging solution, reverting back to the planning phase if things were not going well or if new information was discovered. The second dimension of the framework characterized attributes crucial to the mathematicians' success during each of the problem-solving phases. These attributes included available resources such as knowledge, experience and heuristics and an ability to modify them. It also included affective qualities such as curiosity, intimacy, frustration, defense mechanisms, ethical concerns related to their reasoning, and adherence to intellectual integrity. Finally, this dimension characterized metacognitive skills such as motivation and attention to efficiency and aesthetics.

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A second framework guiding the design of the Pathways intervention and initial coding of data was *the hypothetico-deductive reasoning cycle* (Wallas, 1926; Koestler, 1989; Lawson, 2001). In this framework, human discovery, problem solving and invention is initiated by an encounter with an observation that contradicts one's current expectations. The individual generates multiple hypotheses through analogical reasoning or abduction, many of which may lead to a dead end while others are selected for further investigation. This phase of reasoning is preparation for creative thought, and the individual will often set the problem aside, where it may incubate subconsciously. Later, possibly while engaged in seemingly unrelated pursuits, they may have a flash of insight about the original problem, and a hypothetico-deductive verification process may begin. These steps are iterated until an alternative is generated, tested, and supported on one or more occasions and its competitors have been tested and rejected.

Descriptions of *the engineering design process* have been presented in many different configurations (Atman et al. 1998, 1999, 2001, 2003; Fogler and LeBlanc, 1995; Volland, 1999) but all divide the design process into phases strikingly similar to the previous two frameworks. Atman et al. (2003) noted that a key distinction between expert and novice engineers is that experts often rapidly cycle between multiple phases, even when they are ostensibly engaged in one single phase as viewed in terms of a project plan. Most representations of the design process are also explicitly cyclical. For example, Volland's representation arranges the steps on a circular figure and Atman's incorporates cycling back to earlier steps at every step of the process. The result of any step might be a decision to revisit an earlier step, for example, results of feasibility analysis might illustrate the necessity of redefining the problem.

Our professional development, research methodology and data analysis were guided by these discipline-specific frameworks. Relevant to the findings in this presentation is the use of the frameworks to assess productivity of PLCs in terms of the number of characteristics observed during PLC sessions. Our findings build theory and useful research tools by formulating these observable characteristics into a generalized framework for inquirential engagement, identifying relationships between these characteristics, and determining what features of the professional development are necessary and sufficient to foster productive inquiry.

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### **3. Claim(s) or hypothesis(es) examined in the work (anticipating that veteran projects will have claims, newer projects will have hypotheses):**

Each PLC has unique dynamics and factors influencing their motivation, productivity, and inquirential engagement. In this presentation, we report results from data analysis on one PLC working on their school geometry curriculum. In this PLC, teachers were highly motivated to resolve the problem of the lack of conceptual coherence they perceived when they reviewed state standards, their district standards, and their textbook for a development of the main ideas in the course. During a week-long summer workshop run by STEM faculty these teachers chose to spend their time reorganizing the district standards around central strands of i) quantitative reasoning which repeatedly emphasizes the identification of physical or mathematical objects, measurable qualities of those objects, and units of measurement, ii) geometric constructions as establishing objects with specific measurable and relative properties, iii) arithmetic equations as meaningful statements of relationships among measurable attributes, and algebra as a

generalization of these arithmetic statements, and iv) proof as a development of rigorous reasoning, generalization and justification of student arguments. A STEM faculty member worked with the group to help with the teachers reconceptualize the content of the Geometry curriculum. When the teachers saw a list of apparently unrelated topics mandated by their district, the STEM faculty member helped to outline the overarching ideas that ultimately guided the teachers to create coherent curriculum materials. Subsequently, school geometry teachers met weekly for one three-hour session after school with STEM faculty, and an additional one-hour session with themselves in an effort to revise curriculum around these strands. The STEM faculty participated in the weekly 3-hour sessions to help with the creation of the course materials that the teachers in the group would then pilot in their classrooms.

In this presentation we will discuss the nature of the shifts made by teachers in this PLC relative to their perspective on the geometry course they teach, the materials they use, their district standards and assessments. In addition we focus on shifts in teacher classroom practice as documented using the Reformed Teaching Observation Protocol (RTOP). We will present an in-depth case study of one high-school geometry teacher who has made considerable changes from traditional lecture to more actively engaging students in a reformed classroom setting. An initial increase in her RTOP scores indicated a movement toward a more reformed teaching approach following collaborative lesson development within the geometry PLC. A second increase in her RTOP scores occurred following the summer workshop where the teachers reorganized the district standards around the four central strands.

Interviews and PLC discussions reveal that teachers difficulties changing their classroom practices were partially a result of a lack of experience designing a coherent curriculum. The emphasis on the overarching ideas could not have been achieved without the ongoing guidance of the STEM faculty and project personnel who were active members in the curriculum development process. Much of the guidance from the STEM faculty assumed the form of engaging the teachers in meaningful discourse emphasizing different strands to support changes in their curriculum and classroom practice. In addition to teacher frustrations concerning district curriculum and assessments and the development of new curriculum, the slow process of changing each of the teachers, acceptance of incremental change, and issues of time required to work on creating and adopting new classroom activities, balancing demands of their principal, parents, and district assessment committees were additional sources of teacher frustration. STEM faculty were surprised by the depth of some of these issues and were able to adapt their roles in the PLC to provide more support for teachers to help them better manage these competing concerns.

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#### **4. Evaluation and/or research design, data collection and analysis:**

Project Pathways PLCs have school-based facilitators who are responsible for managing the discourse during the PLC sessions. The facilitators received 18 hours of summer training and attended monthly 3-hour training meetings during the semester. Facilitators were provided general agendas developed by project personnel designed to assist them in promoting meaningful discourse among members of the PLC, although they were encouraged to deviate from the agenda as needed to pursue particular needs of the PLC. Project personnel reviewed video tape

of the PLC sessions and discussed facilitation strategies during 30-minute weekly meetings with the facilitators at their school. All teachers also attended masters-level courses for three hours each week focusing on integrating mathematics and science content related to the PLC activities.

We collected and reviewed video data from every course and PLC session and selected over 100 hours of video from the courses and over 100 hours of video from the PLCs for in-depth analysis. Two research teams engaged in multiple rounds of open, axial, and selective coding (Strauss and Corbin, 1990) relative to issues defined by the three discipline-specific frameworks. At semiweekly research team meetings we compared and discussed coding and constructed timelines indicating the flow of coded activity through each episode. We added major events to these timelines where the teachers made breakthroughs, gave up on their work, argued, etc, then reviewed the timelines for patterns. We generated initial hypotheses about these patterns and interviewed teachers from the project for additional information and feedback on our characterizations of their work. We developed fixed coding categories, criteria and numerical scales and engaged teachers, personnel, and researchers from the project in coding and scoring selected video. Through this process, we identified aspects of the coding scheme that did not adequately apply to the data and on confusing categorization or criteria. Based on this data, we revised the codes and criteria to produce a framework outlining the most crucial factors in a PLC operating productively and the observed relationships among these categories.

The summer workshop and subsequent weekly meetings throughout the semester were video-taped. The video data was coded using the framework mentioned above. Analysis of the coded video highlighted the important factors that influenced the group as they worked on revising their Geometry curriculum. Another source of data gathered occurred in the classrooms of a sample of teachers in the project. Classroom observations were made and were scored using the Reform Teaching Observation Protocol (RTOP). The observations were made beginning in the spring before the project began, and were repeated at least once each semester for the duration of the project. The observations were scored according to the protocol, and observer notes were collected and archived. The observations provide a vehicle for studying the teachers' classrooms over time. In addition to announced observations, the classrooms were video-taped periodically and the video-tapes were archived for later analysis.

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## **5. Key insights (retrospective for veteran projects, prospective for newer projects) that have value for the Learning Network:**

Our analysis of the engagement of one PLC focusing on revising their geometry curriculum and classroom activities has revealed the following key insights:

- Application of our emergent framework of three categories of *dispositional behaviors* related to participants' approach to their discourse reveals that this PLC was highly motivated by resolving issues about a perceived lack of coherence in their curriculum and assessments.
- Application of our emergent framework of three central categories of *process behaviors* generalizing the discipline-specific frameworks for STEM inquiry reveals that a long-term inquired engagement persisted in this PLC to resolve this issue of coherence.
- Guidance and support from STEM faculty was critical to help teachers reconceptualize the curriculum as a coherent whole.

- Teachers had little experience developing curriculum and this work required significant assistance by project personnel and coordination with school and district administrators to provide needed time and support for their efforts.
- Guidance and support from STEM faculty has been critical to help teachers learn to focus on student thinking and learning. In the initial stages of the project, teachers tended to focus on what they wanted students to learn and on “cool” activities. With guidance, teachers were able to shift their focus to key concepts they want students to understand and how they could help to construct that understanding.