Abstract Name: Interaction Between Teacher's Questions and Student Discourse

MSP Project Name: Project Pathways

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120 words Summary

This report discusses findings from an ongoing *Project Pathways* focused on improving secondary mathematics and science instruction. Over the course of the first four years of the project, research findings revealed that the procedural orientation of school curriculum, teacher supports, and school leaders created obstacles for the teachers in incorporating inquiry instructional methods and conceptual curriculum. In response, the *Project Pathways* initiative turned its focus to investigating a precalculus teacher's attempt to implement a research-based conceptual curriculum designed by the project leaders. As a result of using the conceptually oriented curriculum, the teacher transitioned from attempting to force her thinking on her students to attempting to determine and build off of her students' thinking. This session reports on her transition and her students' success.

Section 1: **Questions for dialogue at the MSP LNC.**

a. How do the types and purposes of a teacher's questions change over the course of one year when using a research-based, conceptually oriented precalculus curriculum?
b. How does a teacher's effectiveness in listening and acting on student thinking influence the discourse within the mathematics classroom?

Section 2: **Conceptual Framework.**

Context of the work within the STEM education literature and within your MSP Project:

School Based Activities and Interventions

The *Project Pathways* is a professional development and research project working with secondary mathematics and science teachers to improve instruction. Our project provides school-based interventions that include graduate courses, workshops and leadership for school-based Professional Learning Communities (PLCs) to support all mathematics and science teachers within a school to use inquiry instructional methods and conceptually oriented curriculum. For schools in early Pathways cohorts (1-4) our interventions focused on improving the teachers' content knowledge for teaching secondary mathematics and science, and in supporting the teachers in learning to evaluate and reflect on the effectiveness of their instruction. Research findings from cohorts 1-4 revealed that Pathways graduate courses and PLCs are effective in improving secondary math and science teachers' content knowledge, beliefs about teaching and learning, and the quality of teacher reflection on student learning and teaching. However, it was common for the school curriculum, exams and/or school leaders to be procedurally oriented, which presented obstacles for realizing the profound and substantive shifts we aspired towards in the *Pathways Professional Development Model* we set out to develop.

In response, we elected to focus on four particular schools for Pathways cohorts (5 and 6), which are defined as *Pathways Adopted Schools*. A *Pathways Adopted School* is one in which the school administration supports the project goals and all math and science teachers within the school participate in Pathways interventions. During the summer of 2009 Pathways leaders held a two-week workshop for cohort 5 and 6 mathematics teachers and a separate two-week workshop for science teachers. Following the workshops Pathways faculty and staff worked with teacher teams to create curricular tasks that supported student inquiry in the following content areas: i) algebra II, ii) trigonometry, iii) geometry; iv) precalculus, v) calculus; vi) biology, vii) chemistry; and viii) physics. These efforts revealed positive shifts in the level of student engagement and inquiry within teachers' classrooms. Our project defines student success as improved learning of concepts that are foundational for continued mathematics and science course taking, as assessed by the research-based *Precalculus Concept Assessment* (*PCA*); improved problem solving behaviors; improved beliefs about the methods and nature of mathematics; and improved student engagement in discussing mathematics. Significant improvements were documented in student learning using the *PCA*, although the shifts were not as dramatic as we had hoped. The teachers also found revising their curriculum for even one course daunting. Since the project leadership had previously developed precalculus curriculum and instructional tools that were showing improvements with college level students, we offered a precalculus teacher, Claudia, the opportunity to teach with our conceptually oriented curriculum. This session reports on the impact a research-based, conceptually oriented precalculus curriculum had on 1) Claudia's questioning and effectiveness in listening to and acting on student thinking; and 2) student achievement for the foundational concepts of precalculus needed for success in calculus.

Claudia completed the Pathways two-course graduate sequence during the 2008-2009 year and was concurrently active in a weekly 50 minute PLC composed of 4-6 precalculus teachers. The PLCs primarily collaborated in examining what was involved in understanding and learning key ideas of their courses. During this first year (the year previous to using the curriculum), Claudia made minor shifts in her questioning strategies and attention to conceptual learning, although she did demonstrate significant improvements in her understanding of key concepts of secondary mathematics.

Literature Informing Data Analysis

When examining a teacher's interactions with his/her students, we drew from Piaget's (1955) construct of *decentering*, described as an action of placing one's own perspective aside to understand another person's thinking. We also drew from Steffe and Thompson (2000) who effectively used Piaget's idea of decentering to characterize interactions between a teacher and a student. In their theory they describe decentering actions in terms of first- and second-order observers. A first-order observer listens to another person and may recognize that the person is thinking differently; however, the observer does not attempt to understand what the person is thinking or why the other person is thinking about the situation differently. On the other hand, a second-order observer recognizes that another person's thinking differs from his/her own and then creates a model of the other person's thinking. For example, if an individual makes a claim that two quantities are proportional, a first-order observer may agree or disagree with the statement based on his/her own thinking and understanding of proportionality. However, a second-order observer will ask questions to understand what the other person means by stating that two quantities are proportional. The second-order observer will also attempt to create a model of how the other person is thinking about quantities and proportionality to determine if what they said is valid or not, as opposed to merely agreeing or rejecting the speaker's initial claim.

Carlson, Bowling, Moore, and Ortiz (2007) used the construct of decentering to classify the effectiveness of PLC facilitators in promoting quality discourse among members of the group. In analyzing videos of six PLCs over a two year period, they identified five different levels of facilitator decentering, progressing from the facilitator showing no interest in understanding the thinking or perspective of other members of the PLC to the facilitator acting as a second-order observer. Those facilitators who were able to decenter with respect to the other members of their PLC promoted quality discourse among the group.

Claim(s)

Research-based curriculum[1] (Carlson & Oehrtman, 2010) that supports teachers' development of foundational reasoning abilities and understandings (Carlson, Jacobs, Coe, Larsen, & Hsu, 2002; Oehrtman, Carlson, & Thompson, 2008) through student inquiry and engagement in coherent tasks can lead teachers to become more attentive to student thinking. This in turn will lead to more efficiency in posing questions that build on students' thinking. Student learning is enhanced when teachers' questions built on students' current understandings and have a purpose of helping students engage in reasoning needed to make conceptual connections.

Section 3: **Explanatory Framework.**

Evaluation and/or research design, data collection and analysis

During the 2009-2010 year our research lens was focused on Claudia who used the Pathways Precalculus curriculum. During this year three Pathways members regularly visited her classroom to observe her teach lessons, answer questions she had about the curriculum, and offered suggestions on how to improve her instructional practices.

Collection of qualitative data:

Claudia's two sections of precalculus using Pathways materials were video-taped daily. The videos were digitized and viewed, with select videos analyzed to detect shifts in Claudia's questioning and attentiveness to her students' thinking. This report focuses on the results from analyzing three exemplary videos; one from the first week of class, one from five weeks into the school year, and one from five months into the school year. The teacher-student interactions were coded for types and purposes of questions and the degree to which the teacher was decentering while interacting with her students. We were interested in investigating if the Pathways Precalculus curriculum and teacher support tools impacted Claudia's questioning and attentiveness to student thinking. We conducted multiple classroom observations using the *Reform Teaching Observation Protocol* (*RTOP*) (Piburn, M., Sawada, D., Turley, J., Falconer, K., Benford, R., Bloom, I., et al., 2000) to determine shifts in Claudia's teaching practices as well as the level of student engagement with the mathematics. We also administered the *PCA* to the five sections of precalculus at the *Pathways School* and compared the pre-post shifts of Claudia's students with those of her colleagues.

Data Analysis and Qualitative Findings:

Each of the three videos was coded using Studiocode (Vigital Pty. Limited, 2007) software. The types and purposes of questions were coded in order to determine differences across the three videos. In Excerpt 1, Claudia is working with a group of four students who are trying to answer the following question: What is the meaning of *average* in the context of computing a diver's average score for a dive? Excerpt 1 is an example of Claudia having students describe or explain their thinking. During our session, we will provide more detail about the types and purposes of questions we found Claudia utilize during her teaching. The video was also coded using the five levels of facilitator decentering moves (Carlson et al., 2007). Excerpt 1 was coded as *level* 1 because Claudia showed no interest in understanding her students' thinking. Excerpt 1 is the beginning of the interaction which continues at a *level* 1. Claudia was concerned that the students say the right answer in the way that made sense to her.

Excerpt 1

1	Student 1:	Do you know the meaning of average in this problem?
2	Claudia:	Tell me what you have so far.
3	Student 2:	If the average is 8.55
4	Claudia:	Ok, so…

[1] The curriculum support tools include an online text with model embedded videos, a workbook of scaffolded learning tasks and detailed teacher notes, Powerpoints with dynamic animations used to hold conceptually oriented class discussions about ideas central to the lesson, homework with detailed solutions, etc.

Student 1:	I said that 8.55 would mean average would be like the constant or the, I don't want to say constant
Student 2:	You said approximate
Student 1:	The approximate score.
Claudia:	Keep going
Student 3:	Can we use mean to describe average?
Claudia:	No (laughs)

During the first few weeks of implementing the curriculum, Claudia predominantly probed students to determine if they had a correct answer and did not inquire about the reasoning that led to their answers. This is classified as *level* 1 decentering since she showed no interest in the thinking that supported their answers. As the course progressed, Claudia's questioning began to demonstrate curiosity in understanding how her students were getting answers to problems (*level 3* decentering). However, she exhibited little interest in understanding her students' thinking, nor did she pose questions to support their making connections. Analysis of Claudia's instruction after five months of using the Pathways curriculum revealed that her questioning was frequently for the purpose of understanding her students' thinking so she could leverage her understanding of student thinking to pose additional questions to help them make their own connections.

By the end of the videotaped sessions (see Excerpt 2), students also transitioned to discussing mathematical ideas with each other, with Claudia posing questions to help them overcome their misconceptions and extend their current understandings.

Excerpt 2

Student 1:	How does the angle change if the radius changes? The angle stays the same
Student 2:	Yeah, but if the distance traveled around stays the same, but the radius changes then it will be a different amount of radians.
Student 1:	Oh yeah
Student 2:	It will be inversely proportional
Claudia:	It will be a different amount of radians?

Quantitative Findings:
Claudia was observed five times over the course of two years. The first two observations were completed during the first year of the project and the remaining three observations were completed during the second year while Claudia used the Precalculus curriculum. Claudia made significant improvements in the three areas focused on student engagement and communication: Lesson Design and Implementation, Classroom Culture: Communication Interactions and Classroom Culture: Student/Teacher Relationships. By the end of the second year, Claudia was observed teaching in a more student-centered classroom with her focus on student engagement with the mathematics and students participating in a learning community.

All students who took precalculus during the 2009-2010 school year at the *Pathways School* completed the *PCA* at the beginning of the school year, two times in December, and then again in May. The results reveal greater learning in Claudia's classroom, based on her students' scores on the *PCA* in comparison to the other three teachers' students. Table 1 displays the PCA mean scores (out of 25) for Claudia's students and the other students who took Precalculus.

Table 1
PCA pre and post scores (out of 25) for Claudia's students and the other three precalculus teachers.

	N	***PCA* mean score**	**Standard Deviation**	**Range**
August 2009				
Claudia's students	44	10.87	3.46	5 – 19
Other Precalculus students	70	9.54	3.63	4 – 23
May 2010				
Claudia's students	29	19.24	3.65	8 – 25
Other Precalculus students	58	13.97	3.85	6 – 21

Key insights (retrospective for veteran projects, prospective for newer projects) that have value for the Learning Network

Our analysis of Claudia's questioning and effectiveness in listening to and acting on student thinking (decentering abilities) while using a conceptually oriented precalculus curriculum with teacher support tools has revealed the following key insights:

- Research-based precalculus curriculum that promotes student learning and development of teacher content-knowledge for teaching can realize improvements in teaching and student learning.
- The PLC facilitator decentering moves framework (Carlson et al., 2007) is useful for examining classroom teaching for the purpose of understanding teacher effectiveness in listening to and acting on their students' thinking, and developing foundational understandings and reasoning abilities in precalculus level students.

References

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