Requires reading through the content.
During the 2008-2009 school year all teachers in *Transforming High School A* attended school-based professional learning communities, and either a two-course graduate sequence or a sequence of eight three-hour workshops that met monthly over the school-year. The two courses 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 change together (Carlson, Jacobs, Coe, Larsen, & Hsu, 2002; P. W. Thompson, 1994). The primary purpose of the PLC meetings was to support teachers in engaging in meaningful discussions about issues of learning and teaching central concepts of their courses, and to reflect on the effectiveness of their classroom practices (e.g., watch and discuss classroom videos). Each PLC had a facilitator who was trained by Pathways staff to promote quality discourse among PLC members (Carlson, Moore, Bowling, Ortiz, 2007). The PLC sessions were initially structured to support teachers in learning to attend to the thinking and meanings of both their students and colleagues (Clark, Moore & Carlson, 2007).

During the summer of ’09, 18 of the school’s 42 math and science teachers\(^1\) attended a workshop in which project staff modeled conceptually oriented instruction using research-developed curriculum for precalculus level mathematics. Following this workshop PLC leaders and Pathways faculty collaborated in revising the curriculum for the 6 different courses. The writing teams were grouped by PLC, with each group revising the curriculum for the course (i.e., algebra I, geometry, trigonometry, physics, biology, chemistry) that would be the focus of their PLC. Following the summer curriculum development work, the Pathways faculty and PLC facilitators engaged all PLCs in critical examination and adaptation of their revised curriculum and classroom practices.

### 3. Claim(s) examined in the work:

The school culture, school principal and the curriculum used in secondary mathematics and science schools are primary variables that affect secondary mathematics and science teachers’ instructional practices. Shifts in secondary mathematics and science teachers’ instructional practices and student learning can be dramatically enhanced when teachers, the school principal, school testing and curriculum align with inquiry-based and conceptually oriented teaching and learning.

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

**Collection of quantitative data**

The quantitative data for this study was collected from all math and science teachers at *Transforming High School A* with pre-intervention data collected late in the spring of ’07 and ongoing data collected in fall ’08, spring ’09 and fall ’09 semesters. All mathematics and science teachers completed the *Precalculus Concept Assessment* (PCA) instrument prior to and after the first graduate course, and after completing the second graduate course. In addition all secondary mathematics and science teachers’ classrooms were observed four times over the course of the first year (2008-2009 academic year) and two times during the fall semester of 2009 using the

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\(^1\) These teachers were self identified as instructional leaders within *Transforming School A*
Reformed Teaching Protocol (RTOP). The PCA and RTOP scores were analyzed to detect shifts in teachers’ content knowledge and instructional practices over the first three semesters of the teachers’ participation in Pathways interventions.

**Quantitative Results**

The following chart illustrates the general shifts in PCA scores for math and science teaching in *Transforming High School A* (also referenced as cohorts 5 & 6), with math and science teachers realizing greater gains (and final scores) than science teachers, and course teachers realizing greater gains (and final scores) than workshop teachers.

A comparison of the pre and post RTOP\(^2\) scores from the beginning of the 2008-09 academic year to the end of the 2008-09 academic year revealed very modest gains (5 point gain in pre-post- mean RTOP scores) for science and math teachers in *Transforming High School A*. However comparison of the pre-mean RTOP scores with RTOP scores collected during the fall semester of 2009 revealed a mean gain of 28 points, with the highest gains realized in the RTOP clusters, *Lesson Design* and *Student/Teacher Relationships*. Analysis of this data further revealed significantly greater gains in the course teachers’ RTOP scores as compared to the RTOP scores of teachers who only completed the workshops.

**Qualitative Data Collection, Analysis and Results**

\(^2\) The highest possible RTOP score is 100 with scores of 70 considered very good.
Video data of the 6 PLC sessions were captured and analyzed by six graduate students, with one graduate student collecting and analyzing the data for each PLC. The data for each PLC was coded and analyzed to identify shifts in teachers’ i) content knowledge of the idea(s) under discussion ii) inquiry into student thinking, iii) reflection on their teaching and curriculum in relation to student learning; iv) willingness and effectiveness in continuing curricular revisions. The coded data was distributed to the larger research group (3 faulty, 6 graduate students) and discussed at a weekly 2-hour research meeting to detect emerging patterns.

Analysis of the PLC coded data over the course of three semesters (fall ’08 through spring ’09) revealed that during the first year of the project significant gains were achieved only in PLC teachers’ content knowledge of the ideas central to the PLC discussion. Most of the teachers repeatedly voiced that they either they did not see any reason or that they did not know how to modify their instructional practices. They also did not express or exhibit interest in examining or affecting student thinking or understanding, and thus were not motivated to experiment with inquiry-based instruction.

Analysis of the PLC video data from the current semester revealed that after the summer workshop and curriculum development work all PLCs exhibited fairly dramatic shifts in items ii, iii, and iv above (e.g., inquiry into student thinking, reflection on their curriculum in relation to student learning). Analysis of data from the summer workshop (described in more detail in Carlson and Oehrtman, in preparation) revealed that the research-based precalculus curriculum (worksheets, animations, problems) that they experienced were effective in modeling what conceptually oriented, inquiry based instruction entails. Five of the six PLCs were also observed speaking about the positive influence of their principal in supporting their shifts in their curriculum and classroom practices.

Comparison of mathematics and science chairs with other department chairs from Pathways Cohorts 1-4, relative to their adoption of Pathways philosophies, also supports that the department chairs played a key role in generating teacher interest and willingness to revise their teaching practice towards more inquiry-based and conceptually-oriented instruction. A survey administered to all teachers late in the fall semester of ’09 also supported this finding, with 80% of the participating teachers attributing their willingness to try new curriculum and instructional approaches in their classroom to their principal and department chair.

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

The process of achieving substantive and lasting gains in secondary mathematics and teachers’ instructional practices requires focused and persistent efforts. Teachers need to be supported in acquiring: i) improved understandings of their content knowledge for teaching, ii) an orientation toward affecting student thinking and learning, and iii) ability to pose conceptually oriented questions and engage their students in meaningful conversations about key ideas of a course. Research-based curriculum that includes worksheets and prompts that are designed to support students in making necessary conceptual connections can provide a critical transition for teachers as they learn to shift their instruction to be more substantive, inquiry-based and student-centered.
Our research has revealed that a critical element of transforming the teaching practices of individual teachers is initial engagement of the school principals and department chairs in activities to increase their awareness of the important role they play in affecting teacher beliefs and instructional practices. If school values and support structures do not align with a project’s goals, it is inevitable that barriers such as teacher evaluations, school-based assessments, and standardized curriculum will present obstacles for teachers’ continued instructional improvements.

In closing, our data has repeatedly revealed that the following variables play significant roles in secondary mathematics and science instructional improvements: i) the level of commitment of school administrators to the philosophies of an intervention; ii) teachers’ content knowledge for teaching; iii) teachers’ beliefs about the role of district and state exams in shaping their curriculum and instruction, iii) teachers’ beliefs about students’ abilities and effective instructional practices; iv) teachers’ images of “quality” instruction and the degree to which they believe instruction is about affecting student thinking, v) teachers’ willingness to assess student thinking and use formative data as a tool for reflecting on and improving their classroom practices (Carlson & Oehrtman, in preparation).