

Lenses on Learning:
Effects on Principals' and Other School and District Leaders'
Knowledge about Mathematics Instruction

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Executive Summary
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Why principals?

Overall, U.S. students at 4th and 8th grade levels improved in mathematics on the 2007 International Trends in International Mathematics and Science Study (TIMSS). However, at both levels students performed relatively better on tasks that measured *knowing* math facts and procedures than on tasks that measured *applying* knowledge and conceptual understanding to solve routine problems or *reasoning* to solve mathematics problems that were unfamiliar, complex, or required many steps (National Center for Educational Statistics, 2008). But these are the very skills most needed for success in post-high school education and in many modern careers.

Not coincidentally, Stigler and Hiebert's (2009) analysis of the TIMSS video of mathematics lessons in seven different countries attributes these results primarily to issues of instruction in American classrooms—namely that American teachers tend to teach procedural, rather than conceptual, knowledge of mathematics (also see Hiebert, J., Stigler, J., Jacobs, J., Givvin, K., Garnier, H., Smith, M., et al., 2005). Relatedly, researchers have found that teachers' mathematics knowledge for teaching¹ significantly impacts student gain scores on the Terra Nova (standardized test) even when controlling for student socio-economic status, student absence rate, teacher credentials, teacher expertise and average length of mathematics lessons (Hill, Rowan, Ball, 2005; Ball, Hill, Bass 2005). These authors, and many others, make a powerful case for investing in sustained programs of professional development that extend teachers' mathematics knowledge for teaching and support them in developing instructional practices that improve student learning and achievement.

Through their role as supervisors, school principals play a critical role in supporting teachers' efforts to improve their practice, and in holding them accountable for integrating features of instruction highlighted in professional development into their work with students (Elmore 1996; Hightower et al 2002). In a recent speech, the American Federation of Teachers' president, Randi Weingarten, argued that the system can no longer tolerate perfunctory teacher observations in which the principal sits in the back of the room for a few minutes a few times a year (at best) and then hands the teacher a

¹ Mathematics Knowledge for Teaching is the mathematical knowledge used to teach mathematics. It includes, for example, "explaining terms and concepts to students, interpreting students' statements and solutions, judging and correcting textbook treatments of particular topics, using representations accurately in the classroom, and providing students with examples of mathematical concepts, algorithms, or proofs" (Hill, Rowan, Ball, 2005, p. 373).

‘rating’ of their teaching (Weingarten, 2010). Instead, she proposed a new framework for teacher development and evaluation that puts front and center “constructive evaluations” in which principals dig deeply with teachers into their instruction and how their students are learning, and engage with them in a process of continuous improvement of their teaching.

Informal reports (Grant, Nelson & Stimpson, submitted manuscript), from school-wide mathematics improvement efforts at sites associated with our professional development programs for principals and other school and district leaders, point to principals’ key support and involvement in other key areas as well, such as the following:

- Engaging with teachers and fostering a shared commitment to improving mathematics learning outcomes for all students
- Supporting strong mathematics professional learning programs and systems for teachers, and setting expectations for teachers to integrate new practices into their mathematics classrooms
- Critically examining and modifying school-wide programs, policies, and decision-making processes in order to foster coherence and redress historical inequities in mathematics learning opportunities
- Relating mathematics initiatives to the wider context (e.g., the school improvement plan, district priorities) to maintain continued focus in the face of competing priorities
- Representing mathematics initiatives to, and defending them with, a variety of constituencies even before results begin to be reflected in gains in student achievement

Two studies of principals’ knowledge about mathematics instruction

Research has shown that principals’ Leadership Content Knowledge (LCK) for mathematics – their knowledge of subject matter and their beliefs about how it is learned (and therefore how it should be taught) – has a significant impact on the ways in which they carry out their responsibilities. Among other leadership functions, principals’ LCK for mathematics affects the ways they conduct classroom observations and supervise teachers, their decisions about hiring teachers, their implementation of district curricular policies, and the nature of their communications with stakeholders about instruction (Stein & D’Amico, 2000; Stein & Nelson, 2003).

Because principals’ knowledge about mathematics instruction is so central to their effectiveness as instructional leaders, Education Development Center (EDC) has conducted two major studies to determine how principals’ LCK affects what they attend to when observing mathematics lessons. One study focused on the *Secondary Lenses on Learning: Team Leadership for Mathematics in Middle and High Schools* (Grant et al, 2009) professional development program (The Secondary Lenses [SL] Study) and the focused on the K-8 grade levels (The Thinking about Mathematics [TMI] Study²). These

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studies examined the knowledge of 81 secondary school leaders and 485 elementary and middle school principals, respectively. The TMI study also included a qualitative follow-up component. This paper presents some of the results of those studies.

The Secondary Lenses Study consisted of administering a pre- and post- survey designed to measure participants' understanding of mathematics education reform and aspects of their work related to that reform, to 81 secondary-level school and district leaders from 5 sites distributed across the United States. Four of the five sites were located in large metropolitan areas, with a combination of urban and suburban schools participating in the study; the fifth site was in a rural area. In this study all of the administrators completed a survey, then took part in the *Secondary Lenses on Learning: Team Leadership for Mathematics in Middle and High Schools* course, and then took the survey again after the course.

Secondary Lenses on Learning: Team Leadership for Mathematics in Middle and High Schools (Grant et al, 2009) is a professional development program for mathematics leadership teams comprised at the minimum of the principal, influential teachers/department chair, guidance counselor, and district curriculum director. Anchored in early algebra (a subject that is both high-stakes and a sticking point for many students), it provides team members an extended learning experience so that they can develop a more closely shared understanding of current practices and a common vision for where to lead the mathematics program in their middle and high schools. *Secondary Lenses on Learning* seminars also provide site leadership teams with time and a structure to begin developing both a short-term and long-term plan for addressing needs at their site.

The TMI Study was similarly structured but more extensive. In this study, 485 elementary and middle school principals took a survey to measure their knowledge and beliefs about mathematics learning at the elementary and middle school level. Participants came from 13 sites in 8 different states. Forty-four percent worked in large cities or their environs, forty percent in mid-sized cities or their environs, and the remainder in small towns or rural areas. A randomly selected two-thirds of the participants enrolled in a course on supervising contemporary elementary mathematics instruction (*Lenses on Learning - Supervision: Focusing on mathematical thinking* -- Grant et al, 2006).

The *Lenses on Learning Supervision: Focusing on Mathematical Thinking* (Pearson, 2006) professional development program addresses an audience of K-8 principals and other leaders. The seminar seeks to make possible better alignment between supervisory practices and the changes that are taking place in mathematics classrooms guided by the NCTM's *Principles and Standards of School Mathematics* (2000). In particular, it helps participants learn to attend to the mathematical essence of a lesson and the mathematical thinking of students, and to consider what one might productively talk with teachers about in pre-and post-observation conferences.

After the course, all participants (including those in the control group) took the survey again. The daily work of a subsample of thirteen of these principals was observed to determine the relationship between their knowledge and beliefs as measured by the

survey and how they made judgments about the quality of the mathematics instruction in their schools.

Findings: Effects of *Lenses on Learning* on principals’ knowledge

Secondary Lenses Study (The SL Study). At the outset of the *Secondary Lenses* study those school leaders responsible for the mathematics program (including principals, assistant principals, math coaches, math teachers, and guidance counselors) varied widely in their view of what high quality mathematics instruction is, as shown by the survey data displayed in Table 1. Pedagogical beliefs about how mathematics is learned and should be taught ranged from “traditional” (in the left column), in which principals believe that good mathematics instruction consists largely of teaching basic math facts and demonstrating how to execute mathematical procedures and solve problems, to “constructivist” (in the right column), in which principals believe that good instruction involves helping students build their conceptual understanding of mathematics and develop the comfort and flexibility necessary to solve complex, non-standard problems as well as mastery of facts and procedures.

Table 1
Secondary Lenses Study: Baseline Pedagogical Belief Scores, in Thirds

	Pedagogical Beliefs			Total
	Traditional 1 – 2	Mixed 3	Constructivist 4 – 6	
Total	22% (18)	49% (40)	28% (23)	100% (81)

In this sample of 81 secondary school leaders, at the outset of the study eighteen (22%) held “traditional” pedagogical beliefs and 23 (28%) held “constructivist” beliefs. Almost half of the participants held “mixed” beliefs (40 participants, 49%).

Data from the Secondary School Leaders Study, analyzed using descriptive statistics, resulted in the following findings from the post-survey results:

- *Effects on participants’ pedagogical beliefs.* After participating in *Lenses on Learning* 88% of participants advocated mathematics instruction focused on conceptual understanding, to at least some degree (i.e. scored in the “mixed” or “constructivist” categories), compared to 77% on the pre-survey. Forty percent moved one full category in the conceptual direction, which represents both a substantial shift in beliefs and a shift in the capacity to use those beliefs when judging classrooms. In addition, the number of participants categorized as holding “traditional” pedagogical beliefs dropped from 22% to 12%.

To elaborate, participants shifted in their ability to identify and articulate a rationale for practices that attend to students' thinking and challenge and extend students' mathematical understanding. For the majority of participants, those shifts represented a move from more traditional to more constructivist views of teaching. There was a shift from [a.] thinking of mathematics teaching as demonstrating procedures and immediately correcting mistakes ('traditional') to [b.] valuing particular features of practice such as using real-world contexts, working in groups, or using multiple representations ('mixed') to [c.] recognizing effective practice as offering students and teachers extended opportunities to identify what students understand and have yet to learn and then offering open-ended tasks that have the potential to challenge all learners ('constructivist'). Participants in all roles made shifts along this continuum, with the majority moving towards valuing students having opportunities to challenge and extend their current understandings, use multiple representations, and work concurrently on skills and concepts as opposed to having skills development preceding concept development.

- *Effects on site teams' capacity to work together* -- Analysis of the field test reports indicate that the six sessions of the seminar provided an opportunity for school-based mathematics leadership teams to bond together in ways not often afforded by meetings within the typical school setting. Beginning with the first session, participants identified ways that they individually and collectively contribute to the mathematics program. Most were surprised to learn of numerous overlaps in their efforts and how little they knew about each other's work. Data collected between sessions added detail to these overlaps and often highlighted a current lack of coordination in efforts to improve students' success in mathematics classes. Candor built as teams identified strengths and weaknesses within their setting related to curriculum, instruction, assessment, and opportunities and supports for learning. The work in the final session of developing a short-term and long-term improvement plan highlighted the team's common commitment to significant change. Most groups shifted from being a collection of competent, committed, and hard-working individuals to an informed, focused, and collaborative team poised for action.

In addition, and on an informal basis, *Secondary Lenses on Learning* authors have begun to gather accounts about what has taken place in middle and high school math programs in the years following the participation of a mathematics leadership team in the seminar. According to these reports, at several sites team members' more closely shared vision and understanding of their own site, together with the formulation of concrete plans and commitments, have fueled important changes in their school's math program. The following are examples of what is being learned:

- A district is using *Secondary Lenses on Learning* as a springboard for carrying ongoing, systemic work with elementary and middle school mathematics into the high school through a number of mechanisms, including the following: adopting a

new curriculum; hiring a high school mathematics coach; and strengthening professional development to build teachers' knowledge of mathematics content and their understanding of how to implement assessment *for* learning and grading practices to better support student learning.

- A high school is placing all ninth grade students in Algebra or higher while offering a supplemental math class taught by experienced, respected teachers to students who ordinarily would have not have been placed in an algebra class. They are also working towards eliminating homogeneous grouping. These changes are supported by monthly all-day professional development sessions for all Algebra and support teachers so that they can develop a common approach and deepen their understanding of practices likely to impact the success of the targeted students.
- A high school is taking a multi-pronged approach to target the high failure rate among 9th grade mathematics students and mathematics teachers' tendency to blame students and the middle school program. An important dimension of their approach is a year-long study group to provide a forum for teachers to better understand their students and a structure for discovering how to better support and build student academic and personal confidence.

At least as importantly, at these sites and others many seminar participants have become passionate advocates for goals and practices that broaden access to significant mathematics; that they are going beyond test results as critical sources of data to gauge the success of their mathematics program; and that they are taking a more objective look at how current practices in their own settings might be strengthened. In addition, there are reports that administrators have deepened their commitment to supporting best practices in mathematics and are clearly communicating these priorities to their staffs and to various stakeholders.

Elementary and Middle School Principals (the TMI Study). The pretest showed that elementary and middle school principals range widely in the amount and nature of their knowledge of the mathematics used in teaching and their beliefs about the nature of high quality mathematics instruction. Table 1 shows this distribution.

Table 1
Cross-tabulation of Total Math by Pedagogical Belief Scores, in Thirds
Baseline

		Pedagogical Beliefs			Total
		Trad <u>1 – 2</u>	Mixed <u>3</u>	Construct. <u>4 – 6</u>	
Math Knowledge for Teaching ³	Low	24% (117)	10% (50)	<1% (3)	35% (170)
	Mid	20% (99)	11% (54)	<1% (3)	32% (156)
	High	17% (82)	14% (66)	2% (11)	33% (159)
Total		61% (298)	35% (170)	3% (17)	100% (485)

As explained above in the Secondary Lenses Study, pedagogical beliefs about how mathematics is learned and should be taught range from “traditional” (in the left column), in which principals believe that good mathematics instruction consists largely of teaching basic math facts and demonstrating how to execute mathematical procedures and solve problems, to “constructivist” (in the right column), in which principals believe that good instruction involves helping students build their conceptual understanding of mathematics and develop the comfort and flexibility necessary to solve complex, non-standard problems as well as mastery of facts and procedures. To assess principals’ Mathematics Knowledge for Teaching we used the set of measures of teachers’ content knowledge for teaching elementary school mathematics developed by the Learning Mathematics for Teaching project. (For a description of these measures – their development and validation – see Hill [2007]). We chose these measures because there are currently no established measures of administrators’ mathematics knowledge. We also added six “naked number” computation problems to assess their computational knowledge.

It is noteworthy that in this large sample of nearly 500 elementary and middle school principals 298 (61%) held “traditional” pedagogical beliefs and 17 (3%) held “constructivist” beliefs. That is, many of these principals were not well-positioned to advocate for, or support, mathematics instruction that focused on helping students develop the conceptual understanding and flexibility of thought that would enable them to *apply* mathematics concepts or *reason* to solve unfamiliar, complex problems.

Pre- and post- data from the TMI Principal Study was analyzed using descriptive statistics and multivariate analysis, specifically a combination of ordinary least squares (OLS) and logistic regression, in order to determine the effect on principals’ Leadership

³ The math score ranges on this table are relative to our sample and are not an absolute scale.

Content Knowledge of taking a *Lenses on Learning: Supervision* course. The major findings were:

- Pedagogical Beliefs. The odds of a principal advocating attention to students' conceptual understanding of mathematics, rather than largely their execution of mathematical procedures, was almost 10 times higher for principals who had enrolled in *Lenses on Learning: Supervision* than for members of the control group.
- Math. *Lenses on Learning: Supervision* participation ($b = 0.17, p < .01$) strongly predicted gains in principals' own conceptual knowledge of the mathematics used in teaching.
- Math-in-use. The odds of principals using their mathematics knowledge when analyzing the events of a classroom was more than double for principals who had enrolled in *Lenses on Learning: Supervision* than for the control group.

In sum, *Lenses on Learning: Supervision* was effective at helping elementary and middle school principals move from believing that good mathematics instruction entails demonstrating facts and procedures to believing that it involves helping students build their conceptual understanding of mathematics. After principals enrolled in a *Lenses on Learning: Supervision* seminar they were also better informed than the control group about the mathematics that is used in teaching, and were more likely to actually use that knowledge when observing mathematics classes. (For more detail see Jordan, Goldsmith & Miller, in process).

The *Lenses on Learning: Supervision* course is also designed to strengthen principals' capacity to engage productively with teachers in discussions in pre- and post-observation conferences. (One might consider this a mathematics-centered example of 'constructive evaluation' of teachers' instructional practice as called for by the American Federation of Teachers framework.) Data from our field studies of elementary principals at work in their schools at the conclusion of the seminar show that principals with stronger LCK profiles tend to use more effective criteria when evaluating mathematics classes in their own schools (see Nelson, Weinberg, & Heuer, in process).

Principals with high mathematics knowledge for teaching and constructivist pedagogical beliefs attended to the mathematical thinking of students in the classes they observed in their own schools; noticed how teachers listened to and analyzed that thinking; and paid attention to the degree to which the teacher's instructional moves appeared to be built on an understanding of their students' mathematical thinking. They also discussed these ideas with teachers during classroom observation cycles.

Below are examples two principals with strong leadership content knowledge.

- After completing the *Lenses on Learning: Supervision* course, a principal worked to integrate the *Lenses on Learning Observation Guide* with the

district's required observation tool (which was based on the work of Charlotte Danielson). In doing so, he realized that the potential of the observation process was more than simple evaluation. Rather, he came to see this process as an opportunity to engage the teacher in an exploration of student sense-making in mathematics and how the multitude of variables in a classroom can be manipulated to enhance and deepen student learning. By engaging in collaborative inquiry with his teachers he was able to provide more comprehensive and thoughtful responses than those elicited when using the district required observation tool. This change in his practice allowed the teacher to grow as well.

The following quote from a teacher in this principal's school indicates the value she placed on his approach to supervision:

"... It was in these conversations [with the principal] that I grew, that I became more reflective and became more comfortable talking about the teaching of math. ...The focus of our observations was not for me to perform for a piece of paper in my file, but to help me continue to grow as an educator through meaningful, insightful conversations. I can now see that [my principal] was providing for me the same things I try to provide for my students. He asked thoughtful questions to force me to reflect and see things in my practices in a balanced way so that I was challenged when needed and yet felt safe and supported."

- Knowing that she was going to hold her teachers accountable for improving their instruction, an elementary school principal attended mathematics professional development with her teachers. She sought out additional opportunities for continued learning for herself and her staff by having grade level teams examine the mathematics in a lesson, observe the lesson being taught by the math specialist, and then de-briefing together after the lesson. During her post-observation conferences with teachers, she was able to draw on these common professional development experiences to target specific aspects of student learning and teacher's instruction.

In summary, results from the pre/post LCK surveys in TMI indicate that *Lenses on Learning: Supervision* has been effective in developing principals' eye for how teachers attend to students' mathematical thinking. The TMI study also indicates an improved capacity to discuss with teachers how to move students' thinking forward and advocate for instruction that helps students build the conceptual understanding necessary to solve complex mathematics problems. These are precisely the dimensions on which American students' knowledge needs to improve.

Conclusions

Mathematics instruction in the U. S. needs to emphasize, more than it currently does, helping students learn to *apply* mathematics knowledge and *reason* to solve complex problems, along with knowing basic math facts and procedures.

Principals and other school and district leaders can grow in their discernment about instructional practices that support students to build their conceptual understanding of key mathematical ideas and develop the comfort and flexibility necessary to solve complex, non-standard problems as well as mastery of facts and procedures.

The *Lenses on Learning* courses have been demonstrated to improve principals' knowledge of the mathematics used in teaching and to move their beliefs about high quality mathematics instruction in the direction of valuing conceptual understanding. This knowledge puts them in a good position to both demand and support high quality instruction in their schools.

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