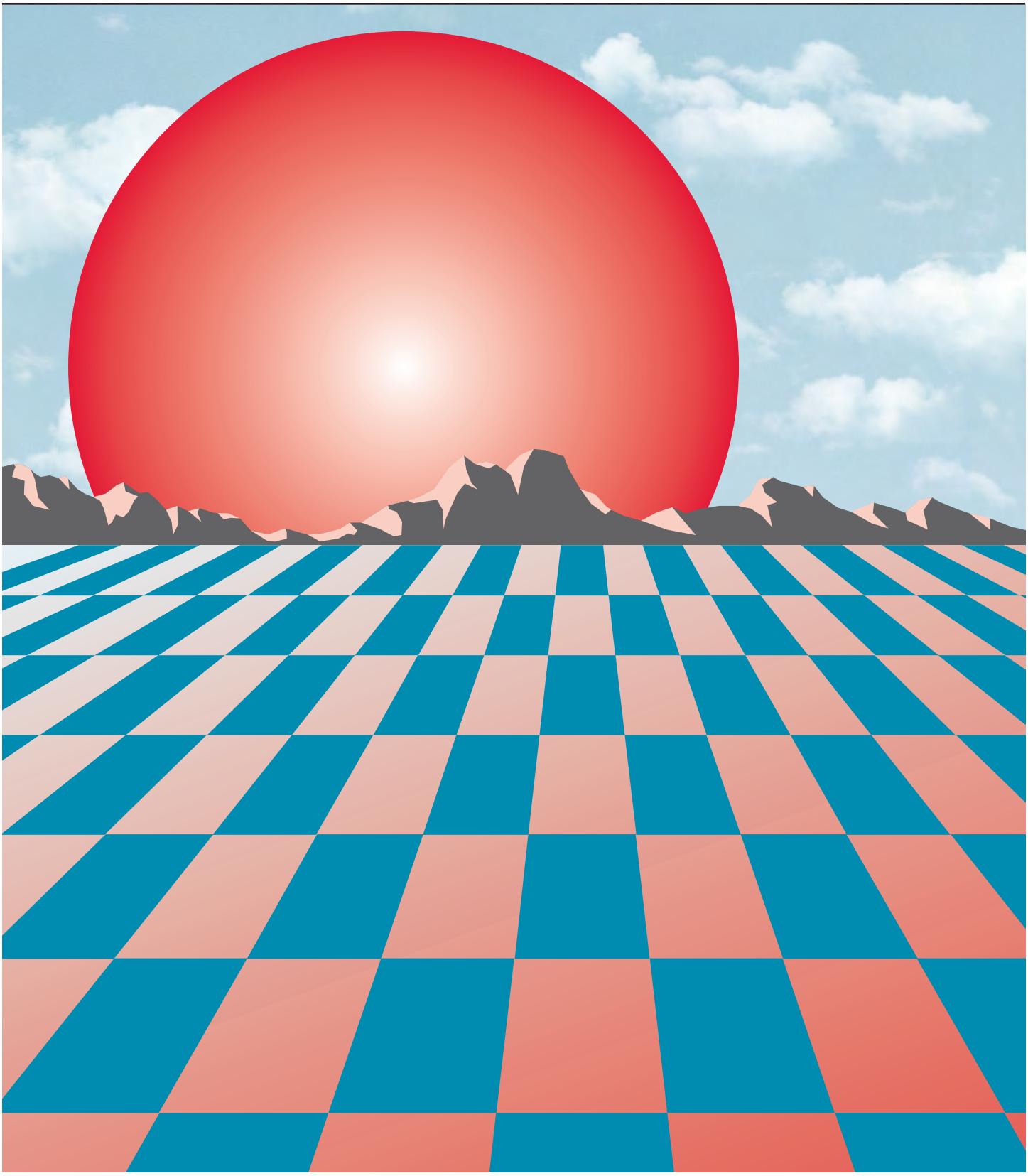
NATIONAL COUNCIL OF SUPERVISORS OF MATHEMATICS

NCSM JOURNAL

of Mathematics Education Leadership

VOLUME 9, NUMBER 2 WINTER 2007



The ***NCSM Journal of Mathematics Education Leadership*** is published at least twice yearly, in the spring and fall.

The editors of the ***NCSM Journal of Mathematics Education Leadership*** are interested in manuscripts that address concerns of leadership in mathematics rather than those of content or delivery. Editors are interested in publishing articles from a broad spectrum of formal and informal leaders who practice at local, regional, national, and international levels. Categories for submittal include:

- Key Topics in Leadership
- Case Studies
- Research Report and Interpretation
- Commentary on Critical Issues in Mathematics Education
- Professional Development Strategies

Note: The last two categories are intended for short pieces of 2 to 3 pages in length

Submission/Review Procedures

Submittal of items for this publication must include three hard copies and a disk copy in text format. Do not put any author identification in the body of the item being submitted, but do include author information as you would like to see it in the ***Journal***. Items submitted for publication will be reviewed by two members of the NCSM Review Panel and one editor with comments and suggested revisions sent back to the author at least six weeks before publication. Final copy must be agreed to at least three weeks before publication.

On the cover:

This issue's cover, created by Bonnie Katz, is a surrealistic landscape that uses natural and geometric forms to indicate the phenomenon of perspective. Readers may enjoy a delightful discussion of vanishing points and projective geometry in Stillwell, J. 2005. *The four pillars of geometry.* New York, NY: Springer.

National Council of Supervisors of Mathematics (NCSM)

Inquiries about and materials for the ***NCSM Journal of Mathematics Education Leadership*** may be sent to:
Mark J. Driscoll
Education Development Center, Inc.
55 Chapel Street
Newton, MA 02458-1060
Email: mdriscoll@edc.org

Other NCSM inquiries may be addressed to:
National Council of Supervisors of Mathematics
9373 S Prairie View Drive
Highlands Ranch, CO 80126
Email: ncsm@forum.swarthmore.edu
ncsm@mathforum.org

Table of Contents

Purpose Statement

The purpose of the NCSM Journal of Mathematics Education Leadership is to advance the mission and vision of the National Council of Supervisors of Mathematics by:

- Strengthening mathematics education leadership through the dissemination of knowledge related to research, issues, trends, programs, policy, and practice in mathematics education
- Fostering inquiry into key challenges of mathematics education leadership
- Raising awareness about key challenges of mathematics education leadership, in order to influence research, programs, policy, and practice
- Engaging the attention and support of other education stakeholders, and business and government, in order to broaden as well as strengthen mathematics education leadership.

Comments from the Editor:
Representing TODOS and NCSM

Mark Driscoll
Education Development Center, Newton, MA • mdriscoll@edc.org

On September 14, 2006, I testified to the National Mathematics Panel in Cambridge, Massachusetts, on behalf of both NCSM and TODOS Mathematics for All. We are repeating those comments here, in hopes that they will inspire you readers to advocate for similar goals and ideas with our national policymakers in mathematics education.

I am Mark Driscoll, from Education Development Center, representing both TODOS and the National Council of Supervisors of Mathematics (NCSM). I am a member of both organizations and Editor of the NCSM Journal of Mathematics Education Leadership. On behalf of both, let me say that we are very grateful to the National Mathematics Panel for inviting us to be represented here today.

My remarks pertain to the Panel's category of interest, "Learning Processes," with implications for the "Instructional Practices" subgroup. Specifically, on behalf of TODOS and NCSM, I want to call your attention to the issue of enhancing the mathematical success of English Language Learners (ELLs), and to the associated issue of galvanizing mathematics education leadership in this regard.

In the past three decades, the number of U.S. children living in households where the native language is not English more than doubled from 9% to 19% (Firestone et al, 2006). The total number of students labeled as "Limited English Proficiency" is 9.6% of the student population, or 4.5 million (Abedi, 2004). Many of these children are taught mathematics in English, which adds a considerable learning hurdle for them. In these remarks, I will cite some research results and promising practices that give shape to an imperative, yet a hope-filled imperative, regarding our helping ELLs become more successful in mathematics.

In brief, we believe it imperative to *teach ELLs the academic language of mathematics, not as vocabulary drill, but in the context of working on mathematics tasks that are challenging and have high cognitive demand.* We also believe it imperative for national leaders to encourage and support district and school leaders in building teachers' capacities to teach ELLs in this way.

I said these are *hope-filled* imperatives, because results, tools, and practices already exist that can help transform ELLs' experience in mathematics classrooms. We lack coherent programs for scaling up their use, and that requires galvanized leadership. Let me elaborate.

Consider first the results of the QUASAR project from the 1990's (Silver & Stein, 1996; Silver et al, 1995). QUASAR, a five-year intervention in six middle schools serving poor communities, was both a school demonstration project and a complex research study of educational change and improvement. One strand focused on types of classroom mathematics tasks and on the nature of student engagement with tasks (Henningsen & Stein, 1997). The researchers distinguished tasks according to *cognitive demand*. They noted that different mathematics tasks make different levels of cognitive demand and that the cognitive demand of a task can change during a lesson, depending on what teachers and students do in implementing them.

Using extensive classroom observation and analysis, along with a project-developed Cognitive Assessment Instrument,

the study concluded that student learning gains were greatest in classrooms in which instructional tasks consistently encouraged high-level student thinking and reasoning (e.g., conjecturing, justifying, interpreting), and least in classrooms in which instructional tasks were consistently procedural in nature. In brief, the project led to the conclusion that, in order to foster *all* students' success in mathematics, teachers must support students' cognitive activity by providing a regular diet of work on meaningful tasks for which neither the complexity nor the cognitive demand is reduced — i.e., tasks that involve 'doing mathematics.'

For ELLs, the phrase "meaningful tasks" takes on even more complexity because of the role of academic language. This provides a pointed challenge to teachers and administrators. Particularly because of current testing demands, many are tempted to address ELL needs by separating language work from mathematics work, with strategies such as vocabulary drills (Firestone et al, 2006). Often, this lack of integration of language and content development results in a lack of active engagement by ELLs in the mathematical work being done in their classrooms (Brenner, 1998).

However, despite the added challenge of academic language, there is no need to cease heeding the QUASAR message, as evidenced in the story of one 5th-grade teacher, whose work has been studied by Chval and Khisty (Chval & Khisty, 2001; Khisty & Chval, 2002). Sarah (a pseudonym) teaches in a school that is nearly 100% Latino in one of the poorest neighborhoods in a large urban school district in the Mid-West. In the focal year of the study, the average child entered her classroom half a year behind the expected 4.8 in the ITBS, with only five of the 24 students performing at the 4.8 level or above. After just eight months in Sarah's classroom, her students outperformed the other fifth-graders in her school, as well as other fifth-graders in her district, and 15 of the 24 (62.5%) performed at the 5.8 level or above. This success was typical of Sarah in other years.

In tracing the roots of this success, Chval and Khisty document a consistent use by Sarah of writing assignments and classroom discourse related to challenging mathematics problems, used as occasions for clarifying — not simplifying — mathematical language. To get a flavor for how such discourse works, consider the following brief interaction between Sarah and her students (p. 23 of Chval & Khisty, 2001; a similar exchange is recorded on p. 8 of Khisty & Chval, 2002). It is the first week of school and the children have been engaged in a challenging geometry problem. The word "congruent" has been introduced:

Sarah: Look at that word everyone. Congruent. What does that mean?

Student: Like another copy.

Sarah: An exact copy. Because here, look here is the circle. Is this circle congruent to that circle?

Chorus: No.

Sarah: No, they're not exact copies. They're similar, they're both circles, but they're not exact copies.

Of course, Sarah is but a case of one. However, we believe that scaling up success like hers is possible, if our leaders — at national, district, and school levels — act to increase attention in teacher education to the importance of:

1. *integrating* content and academic language development in classroom instruction. (See, for example, the framework and tools in Garrison et al, 2006.)

2. attending to *cognitive demand* in the mathematical work done by all students, but especially by ELLs. (See, for example, the framework and tools in Stein et al, 2000)

3. creating learning environments that use *multimodal mathematical communication* — speaking, writing, diagramming, etc — to reinforce the learning of mathematical language.

A quick example can elaborate the third bullet. Along with several colleagues, I am currently involved in an effort by New York City's Office of English Language Learners to solve a problem through the professional development and collaborative efforts of teachers, coaches, and administrators. The problem: In the city, there is an unexplained achievement gap in mathematics between ELLs and others. The participants: middle-school teams comprising assistant principals, math coaches, and ESL specialists. The goal of the effort: From lesson preparation to interacting with students in the classroom to analyzing student work, each school team will be more effective in understanding evidence of difficulty with academic language as well as evidence of difficulty with mathematical concepts, and will inform the teaching and support of ELLs accordingly.

A core activity in this effort has been the gathering and analysis by the school teams of student work on challenging mathematics problems. We have chosen to use problems primarily from a project[1] that is currently field testing professional development materials focused on geometric thinking. We believe that suitable geometry problems invite multimodal mathematical communication, especially when the student work being gathered is in the form of newsprint presentations by small groups of students.

For example, one of the problems pertains to geometric dissections and first asks solvers to cut up a given parallelogram and rearrange all the pieces to make a rectangle. Then, it tells them: "In a sequence of pictures, show where you decided to cut and how you rearranged the pieces." Next, "Describe in words where you decided to cut and how you rearranged the pieces." And, ultimately, "Will your method allow you to transform any parallelogram into a rectangle?" The transitions from pictorial to verbal explanations and from specific cases to mathematical generalization provide teachers ample opportunities to clarify and develop mathematical language for students. During the coming year, we hope to determine how significant such opportunities are in creating effective learning environments for ELLs.

Thank you for your time and attention.

References

Abedi, J. (2004) The No Child Left Behind Act and English language learners: Assessment and accountability issues. *Educational Researcher* 33(1) 4-14.

Brenner, M.E. (1998) Development of mathematical communication in problem solving groups by language minority students. *Bilingual Research Journal* 22: 2, 3, & 4. 103-128.

Chval, K. & Khisty, L. (2001, April) Writing in mathematics with Latino students. Presentation at the Annual Meeting of the American Educational Research Association, Seattle, WA.

Firestone, W.A., Martinez, M.C., & Polovsky, T. (2006, June) Teaching mathematics and science to English Language Learners: The experience of four New Jersey elementary schools. New Jersey Math Science Partnership. Unpublished paper, retrieved from http://hub.mspnet.org/index.cfm/13070

Garrison, L. Amaral, O. & Ponce, G. (2006). UnLATCHing mathematics instruction for English learners. *NCSM Journal of Mathematics Education Leadership*, 9 (1), 14-24.

Henningsen, M. & Stein, M.K. (1997) Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level mathematical thinking and reasoning. *Journal for Research in Mathematics Education*, 28(5), 524-549.

Herman, J.L. & Abedi, J. (2004) Issues in Assessing English Language Learners' Opportunity to Learn Mathematics. CSE Report 633. Los Angeles: Center for the Study of Evaluation, University of California, Los Angeles.

Khisty, L.L., & Chval, K. (2002). Pedagogic discourse and equity in mathematics: When teachers' talk matters. *Mathematics Education Research Journal*, 14(3), 154-168.

[1] Fostering Geometric Thinking in the Middle Grades, NSF EHR-0353409. Education Development Center, Newton, MA., 2004-2008. Mark Driscoll and June Mark, Co-Principal Investigators.

Masini, B. R. (2001, April). Race differences in exposure to algebra and geometry among U.S. eighth-grade students. Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.

Minicucci, C. (1996). Learning science and English: How school reform advances scientific learning for limited English proficient middle school students (Educational Practice Report No. 17). Santa Cruz: University of California, National Center for Research on Cultural Diversity and Second Language Learning.

Siegler, R.S. (2003). Implications of cognitive science research for mathematics education. In Kilpatrick, J., Martin, W.B., & Schifter, D. E. (Eds.) *A research companion to Principles and Standards for School Mathematics.* Reston, VA: NCTM. 219-233

Silver, E.A., Smith, M.S., & Nelson, B.S. (1995) The QUASAR project: Equity concerns meeting mathematics education reform in the middle school. In W.G. Secada, E. Fennema, & L.B. Adajian (Eds.), New directions for equity in mathematics education New York: Cambridge University Press. 9-56.

Silver, E.A. & Stein, M.K. (1996) The QUASAR project: The "revolution of the possible" in mathematics instructional reform in urban middle schools. *Urban Education*, 30, 476-522.

Stein, M.K., Smith, M.S., Henningsen, M.A., & Smith, E.A. (2000) *Implementing standards-based mathematics instruction: A casebook for professional development.* New York: Teachers College Press.

Lessons from a University-K-12 Partnership:
Five Strategies for Mathematics Professional Development

Matthew G. Jones
California State University, Dominguez Hills

For the past four years, I have worked on a series of funded projects aimed at improving the teaching of mathematics in the upper elementary and middle grades, work for which I had no formal training. In that time, I have moved from being a co-facilitator of an institute to being the primary investigator of a comprehensive professional development partnership between my university and a local K-8 district. While I initially approached the work of teaching teachers from the naïve principle, "Show them the depth and richness of the mathematics they teach," I have now become well-acquainted with the literature on effective mathematics professional development, and through the literature and personal experience, have refined this notion into a set of five empirical principles for the design of professional development.

It is likely that some of these principles will be familiar to most of those experienced in professional development. However, I believe it is the combination of multiple strategies that give the program its strength. I share these five principles to encourage others in the field to consider the synergy possible in using multiple strategies. For more detail on the design of my current project and its basis in the research literature, see Author (2005, November; 2006a).

1. Teachers' experience with mathematical content must be readily connected to the mathematics that the teachers must teach but deep enough to foster new learning.

While it is true that teaching middle school teachers about trigonometric proofs would enhance their content knowledge, and the material is full of rich connections, it is too far removed from the middle school curriculum, where the focus is simply on understanding angles, polygon angle sums, and basic ideas of similarity and congruence. The phrase "readily connected" means that some portion of the task must actually overlap with a task that the teachers can use with their students. Yet the task must also be rich enough to challenge the teachers to develop a new understanding of their content.

2. Teachers must grapple with how reform-oriented teaching is incorporated into real classrooms.

Mere exhortations to teachers, "Please implement these ideas because your students will better understand mathematics," will get you very little. Contrary to popular myth, when given the time, teachers can and do read research and glean insights from it. In my professional development courses, I ask teachers to read research when I believe that research will enable them to expand their vision of what is possible or reflect on their current practices. This often means showing teachers research on how students perform when certain kinds of changes are made in the classroom. The article by Hufferd-Ackles, Fuson, and Sherin (2004) provides a good example. In this article, the researchers describe a framework for understanding the changes in practice that comprise movement toward reform-oriented teaching. An article such as this one promotes the teachers to reflect on how various components of teaching interact to produce a reform-oriented classroom. However, such discussions are only the beginning.

Teachers must also see teaching as it is enacted. Recently, a number of authors (e.g., Smith, Silver, and Stein, 2005) have produced written or video cases. Such cases allow teachers to delve into the details of a single lesson to explore what is involved in enacting the kind of teaching promoted by reformers. This allows teachers to see teaching in all the rich, real detail that a daily lesson encompasses. It is a

complement to the theoretical perspective provided by research, in that it focuses not on the theory driving the instructional decisions, but on the practical decisions that teachers must make on an everyday basis in order to reform their classrooms.

3. Teachers must be given time to translate the ideas of professional development into ideas they can enact in their own classrooms.

How does the vision we promote impact the classroom? It happens through planning. In my courses, I employ several classroom teachers (co-facilitators) who have already implemented reform ideas. I then explain the process of unit planning, adapting but simplifying ideas from Wiggins and McTighe (2005). Then, my co-facilitators and I each sit with a group of teachers and help them plan, typically a one- or two-week unit, focusing on using problems adapted from the content I have presented and also drawing on resources such as the NSF curricula. Teachers collaborate, using these resources, to craft a unit of instruction that they then try out in their classrooms.

4. Teachers need support as they implement new ideas.

The teachers I have worked with have the best of intentions in using the units designed during professional development. But, given the constraints of everyday teaching, it helps if the teachers can rely on the co-facilitators and me to provide assistance in implementing the units. Therefore, the co-facilitators and I go into classrooms and either model or observe lessons, and may interact with the students as well, acting as a second teacher by assisting the students as they work on problems individually or in groups.

5. Teachers need the opportunity to reflect on the impact of the changes.

Finally, teachers need the opportunity to study the data on the impact of the changes. Typically, we provide follow-up meetings in which teachers bring student work and examine students' performance. Teachers may be surprised at what their students can do, or they may find that fewer students understood the lesson than they thought. In either case, student work and data from our observations lead to important conversations about what is and is not effective in getting students to learn mathematics.

Project evaluation thus far indicates that teachers have been able to enact changes in the classroom, and that different aspects of the professional development were most effective for different teachers (Author, 2006b). I believe that the lessons shared here will be of use to other mathematics education leaders who work to provide quality professional development to teachers.

References

Author (2005, November). Paper presented at the conference of the California Educational Researchers Association, Long Beach, CA.

Author (2006a). Manuscript submitted for publication.

Author (2006b). Manuscript in preparation.

Hufferd-Ackles, K., Fuson, K. C., & Sherin, M. G. (2004). Describing levels and components of a math-talk learning community. *Journal for Research in Mathematics Education*, 35, 81-116.

Smith, M. S., Silver, E. A., & Stein, M. K. (2005). Improving instruction in algebra: Using cases to transform mathematics teaching and learning. New York: Teachers College Press.

Wiggins, G. P., & McTighe, J. (2005). *Understanding by Design: Expanded Second Edition.* Alexandria, VA: Association for Supervision and Curriculum Development

Manager to Instructional Leader:
Developing Teachers as Leaders

Ted Hull
NCSM Regional Director for Southern 2 and Chair of NCSM's Equity and Leadership Initiative

Now, more than ever, educational leaders are being challenged to engage and empower staff with the intent of improving student achievement in mathematics. This transition in the role of the school principal, often referred to as a shift from manager to instructional leader, is difficult and challenging. School principals, by their line position, are vested with the authority to make change. Yet, these same individuals may be unfamiliar with the requirements necessary to adjust their use of authority to meet the new leadership demands in the form of influence or power. Furthermore, they appear to have no united plan with mathematics leadership staff for encouraging, supporting and sustaining teacher behavior change with any degree of scale. They unfortunately and unsuccessfully still rely on the more traditional top-down management authority, based on coercion and compliance, instead of shared leadership power, based on pressure and support (Corallo and McDonald, 2002), to impact teachers and create the positive conditions for change. Since mathematics leadership staff positions are not normally vested with the same authority, the two sides fail to connect in providing a cohesive message.

To work collaboratively in promoting and supporting entire school change initiatives, mathematics leadership must understand this power dynamic. Changes in school instructional practices will fail if the principal is apathetic toward or against the recommended changes. Mathematics leadership in staff positions, such as coordinators, supervisors, coaches, and other school or central office personnel responsible for changes in mathematics, must be aware of the power dynamics of school principals as well as their own power position. Collaboration is an invaluable skill since, in most instance, the support staff named above are the link between teachers, principals, and reform mathematics. Principals and mathematics leadership must combine their energies to engage and empower classroom teachers and teacher teams in effectively changing mathematics instructional techniques.

This ends in one important, but perhaps uncomfortable, fact for change. If a person is in a leadership position, line or staff, then he or she must actually lead, not just manage. To meet the new demands of leadership, to increase student achievement in mathematics, and to properly develop teachers as leaders, four elements must merge. The leaders, line and staff, must:

1) provide clearly articulated expectations of teacher behaviors that impact student achievement,
2) provide timely and accurate feedback to the teachers,
3) strategically develop teacher leadership in collaborative teams, and
4) take time to reflect upon the ensuing results.

The nuances of leadership, authority, power, pressure, and support are complex. To successfully accomplish these tasks, principals and mathematics leadership must work together in setting the direction. To improve student achievement is to improve classroom teaching (Marzano, 2003). With the focus of improving classroom instructional practices, leaders must thoughtfully consider the current implementation status of each classroom teacher, the desired strategy to be implemented, and the actions required to move each teacher and the school to the next level of proficiency with the desired strategy. Since individuals adapt to change at different rates (Hord, 1987), it is

important to clarify and focus the efforts of all instructional leaders so a consistent message is communicated as to what strategies are to be employed in the classroom.

Clear expectations

In providing clear expectations and focus for teacher classroom behavior, it is valuable to know both the current and the desired approach to teaching mathematics. Current mathematics instruction in American schools is very predictable and usually fails to successfully teach mathematics to a majority of traditionally underserved students. According to the Third International Mathematics and Science Study (TIMSS), many mathematics teachers follow the same instructional routine of review, demonstration, practice, and assignment (U.S. Dept. of Education, 2000).

This approach, also identified by the National Assessment of Educational Progress (NAEP) research, has dominated the mathematics classroom and resulted in a distinct achievement gap among various student populations (Wenglinsky, 2004). If achieving equity and closing the achievement gap in mathematics is desired, this instructional routine will need to be changed to one that is more engaging and challenging for all students. In mathematics, more effective, inclusive approaches have been identified.

For example, instructional strategies that present a challenging problem to small groups of students are highly effective (Marzano, 2001). Effectiveness further increases when students are allowed to compare and discuss their various problem-solving approaches to well-designed tasks while working in small groups. Through skillful questioning, the mathematics teacher can draw the mathematical thinking from the students and guide increased understanding (Boaler, 2002). From these and other proven strategies, leaders must collaborate with teachers to decide which actions, behaviors, and techniques are needed in the mathematics classroom and then make the strategies known to all teachers. The leaders must regularly monitor the instructional staff in the progress they are making toward achieving the effective use of these strategies and take the needed time to provide this information to the instructional staff in positive, supportive feedback.

Feedback

Feedback is a key element in getting results in student achievement (Marzano, Walters, and McNulty 2005; Schmoker, 1999), and individuals need feedback provided by an outside source to gauge the accuracy of their actions (Brandt, 1998). Without a process to provide timely feedback to teachers, there is no way to monitor the effects of instruction and develop the sense of teacher efficacy. Feedback that guides expectations toward "continuous, incremental improvements [provides] the real building blocks of sweeping systemic change that is rapid — and attainable" (Schmoker, 1999). To be meaningful, feedback must be specific, and to be specific, feedback must address a clearly articulated achievement objective.

In education, providing feedback to teachers has acquired a negative connotation. For the most part, teachers work in isolation (Short and Greer, 2002) and receive feedback in an impersonal, contrived situation that addresses broad, indistinct goals. For many classroom teachers, the principal provides the only feedback. It is presented in the form of cumulative data gathered from required annual state assessment results and annual summative classroom observation forms. With these forms and numbers, little connection is made between the teacher's routine actions and student results, thereby decreasing efficacy. The numbers, whether good or bad, seem totally disconnected from the reality of day-to-day teaching. This is evaluative feedback required by law and based on authority. Teachers need supportive feedback in order to sustain change efforts.

Herein lies one of the major difficulties in shifting from the old manager authority system to the new instructional leadership one — giving worthwhile, supportive feedback is difficult and demanding. This is particularly true for principals who must operate in both evaluative and supportive realms, but it is also difficult for mathematics leadership staff unaccustomed to providing supportive feedback.

This necessary shift will require instructional leadership skills, not management ones. The ability to thoughtfully garner support from the mathematics teachers by setting clear goals, collecting classroom visitation data and providing timely and accurate feedback to the teachers in a positive way is of utmost importance. These responsibilities require instructional leaders to employ a reflective process.

Before initiating the reflective process, the instructional leader must identify small groups of mathematics teachers and the instructional initiative or strategy to be reviewed. Schmoker (1999) recommends taking on small, manageable tasks to increase the likelihood of successful implementation. Overwhelming tasks never seem to get completed. For this reason, the leaders should begin with a reasonable

size group of teachers such as third grade, high school mathematics department, or perhaps Algebra 1, and perhaps one or more complementary strategies.

Developing Teacher Leaders:

In most situations, one individual is not going to be able to create and sustain change initiatives to any degree or scale. Collaborative teams are fundamental to change (DuFour et al, 2004). Further, effective teams need effective team leadership. In developing and running collaborative teams, the duties of the principal and team leader are intertwined. The team leader is acting as an extension of the authority of the principal. The team leader must regularly schedule, plan, attend, and guide the team meetings. They will need to maintain the focus of the meetings on student achievement, instructional strategies, content, pacing, success, and intervention. The principal will need to be aware of the meeting schedule and topics, and periodically attend the meetings.

The team leader will be charged with the responsibility of maintaining open communication with the principal and team members, as well as any mathematics support staff. The principal will need to schedule regular meetings with the team leaders to promote the communication and keep clear the school expectations.

The team leader will be responsible for charting the progress of the students impacted by the collaborative team. He or she will need to gather and chart student achievement data for the team members and the principal. The principal will need to use this data as part of a larger review of progress by looking at team data, grade level or course data, and school data.

One additional power that can be distributed is classroom visits for supporting the implementation of instructional strategies. Regularly visiting classrooms is a must. Through the act of entering classrooms for support, the leader has added credibility and accuracy to his or her comments. Teachers must also be encouraged to visit classrooms to remain informed and develop a sense of community. "Peer pressure, when coupled with valued professional feedback, increases teacher engagement. Teachers do their best work when they collaborate with demanding colleagues." (Williams, 1996).

To be successful, these actions need the support and backing from the school administration and formal mathematics leaders. A list of leadership actions is attached to this article (list 1). The list is designed to help formal leaders recognize their responsibilities in encouraging and developing teachers as leaders.

Reflective process

With this group of mathematics teachers and the expected strategy, behavior, or technique in mind, the instructional leaders are prepared to consider, and reflect upon teacher leadership within collaborative teams as well as the other identified elements. Individuals do not change at the same rate, nor equally respond to the same stimuli. In efforts to improve classroom practices, one size does not fit all. Time to reflect upon the change, growth, and progress will help to sustain momentum, target specific areas of need, and identify successes. In collaborative teams, teachers are encouraged to reflect upon the work of the team and student progress. Leaders must also reflect upon the work and progress of the school.

Summary

Leaders possess a great deal of power. To improve achievement opportunities for students, they will need to use this power wisely and efficiently. Many positive, effective initiatives for classroom change never get implemented because leaders do not actually plan for the implementation stages. Leaders must learn how to build a critical mass of teacher support for change by empowering teachers to be an integral part of the change process. If an initiative is to be effectively implemented, then teachers need to be supported and encouraged as well as empowered as leaders. Specific, positive, thoughtful feedback is a major key in accomplishing this end. If this feedback is to be thoughtful, then it stands to reason that the leader must engage in a reflective process.

As noted, current conditions in the mathematics classroom are not generally closing student achievement gap. These conditions will not change without intervention from the leader. Large, unsupported change efforts often fail due to the inability of the administrator to monitor implementation and provide meaningful feedback to the individuals involved. With this list as a starting place, the leader will be able to select actions that will engage and empower teachers in school change. By highlighting specific, effective procedures, and targeting willing and able staff, the leader can build support for the desired change in mathematics instruction, thus ensuring every child a high quality, challenging, and effective mathematics education.

Administrative Support for Teachers as Leaders

LIST 1

In developing teachers as leaders, the school administrator will promote:

Collaboration by:

Leading efforts to form teams
Clarifying roles and expectations
Periodically attending meetings
Periodically meeting with current team leader
Periodically meeting with current team leaders
Garnering teacher input and respecting it

Training by:

Attending professional development training with teachers or teacher leaders
Guiding teachers in selecting school-wide strategy selection
Encouraging and promoting teacher training on strategies

Classroom visitations by:

Visiting classrooms with specific list of elements
Working with teachers to develop the list
Working with teachers to provide feedback
Working with teachers to promote peer coaching

Data interpretation by:

Analyzing data with teacher leaders
Assisting in defining:
• What does the data tell us?
• What does the data not tell us?
• What additional data do we need?

Intervention by:

Working with teachers to plan intervention strategies
Balancing inside classroom and outside classroom intervention

Collaboration with Central Office and Support Staff by:

Encouraging teacher leaders in meeting regularly with these individuals
Ensuring consistency and coherence in message delivery
Working with teacher leaders in setting school direction

References

Boaler, J. (2002). *Experiencing school mathematics: traditional and reform approaches to teaching and their impact on student learning.* Mahwah, New Jersey: Lawrence Erlbaum Associates.

Brandt, R. (1998). *Powerful learning.* Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Corallo, C. and McDonald, D. (2002). *What works with low-performing schools: a review of research.* Charleston, W. VA: AEL

Downey, C. (2004). *The three-minute classroom walk-through: changing schools supervision practice one teacher at a time.* Thousand Oaks, CA: Corwin Press, Inc.

DuFour, R, DuFour, R., Eaker, R., and Karhanek, G. (2004). *Whatever it takes: how professional learning communities respond when kids don't learn.* Bloomington, Indiana: National Educational Service.

English, F. (2000). *Deciding what to teach and test.* Thousand Oaks, CA: Corwin Press, Inc.

Geisler, J. (2003). The Power grid of Leadership. Retrieved May 17, 2005, from http://www.poynter.org

Hord, S. et al. (1987). *Taking charge of change.* Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Marzano, R., Walters, T., and McNulty, B. (2005). *School leadership that works: from research to results.* Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Marzano, R. (2003). *What works in schools.* Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Marzano, R. (2001). *Classroom instruction that works: researched-based strategies for increasing student achievement.* Alexandria, VA: Association for supervision and Curriculum Development (ASCD).

Schmoker, M. (1999). *Results: The key to continuous school improvement.* Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Schmoker, M. (2004, February). Tipping point: from feckless reform to substantive instructional improvement. *Phi Delta Kappan*, volume 85 (issue 5). 424–432.

Short, P. M., and Greer, J. T. (2002). *Leadership in empowered schools: Themes from innovative efforts.* Columbus, OH: Merrill Prentice Hall.

U.S. Department of Education. (2000). *Before it's too late: A report to the nation from the National Commission on Mathematics and Science Teaching for the 21st Century.* Jessup, MA: Education Publications Center.

Wenglinsky, H. (2004, November). Closing the racial achievement gap: the role of reforming instructional practices. *Educational Policy Analysis Archives.* volume 12 (number 64). 1-23.

Williams, B. (1996). *Closing the achievement gap: A vision for changing beliefs and practices.* Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Whitaker,T. (2002). *Dealing with difficult teachers.* Larchmont, N.Y.: Eye on Education

Reforming Mathematics to Meet the Needs of Exceptional Learners

Lesa M. Covington Clarkson and Lesley Craig-Unkefer
University of Minnesota

Introduction

Reform mathematics is researched mathematics that is based on the National Council of Teachers of Mathematic's (NCTM) Principles and Standards (1989, 2000). These standards advocate that every child have access to stimulating, real-world mathematics that includes problem solving. These standards encourage a more constructivist approach to the teaching and learning of mathematics. Constructivist teaching and learning means some group work and hands-on activities will probably be included in the lesson.

The standards and the expectations outlined by NCTM for opportunities that will promote mathematics knowledge apply to all children, those who are typically developing as well as those children with special needs. A glance at the data from many school districts reveals that special education students are still struggling in the mathematics classroom even as their peers are making gains. Identifying effective strategies that will reduce the achievement gap between these two groups is crucial to their school success. More often than not, these strategies focus on classroom techniques rather than how the administration or mathematics supervisors can and should be key players.

The purpose of this paper is to review simple, yet effective strategies to assist administrators and teachers in promoting learning opportunities for children with special needs. First, we will describe a mathematics curriculum in an elementary classroom and then suggest strategies that administrators can consider to support teachers as they enhance the learning experience of children who receive special education services. The target population is students who are fully included in the regular education classroom.

Background

The National Science Foundation (NSF) funded the development of three elementary curricula in the early nineteen nineties. These curricula include Everyday Mathematics, Trailblazers, and *Investigations*. The purpose of this curricula development project was to insure that all children had access to "good" mathematics as prescribed by the NCTM standards. Once the 1989 standards were published, teachers across the country tried to implement them even though their curricula at that time rarely included content and pedagogy that was consistent with the standards. These curricula, then, were to provide resources for teachers as they were implementing the standards. Because these curricula are consistently being used in elementary classrooms across the country, it is imperative that we examine the impact of these curricula on the mathematics experiences of exceptional students.

Mathematics

An example of a reform mathematics unit is number theory. The unit builds on the student's prior knowledge of factors and products. This is the first unit for the Grade 5 *Everyday Mathematics* curriculum. In this unit, the activities are designed to start all students on "equal footing". Topics within this unit include: review of multiplication facts, factors, division, prime numbers, and square numbers. The structure of the unit includes assessment at three levels (ongoing, product and periodic). Included in the *Everyday Mathematics* curriculum are curricular options for learners with exceptionalities as well as ESL learners. In addition, there are suggestions for individualization of a task as well as whole class, small group, and dyadic options for instruction.

Now consider this unit with an overview of adaptations at two levels, administrative and classroom based. Adaptations are changes to the learning task and considered temporary and can be reduced over time (Janney & Snell, 2000). For example, classroom adaptations that may be implemented at the beginning of the school year would decrease over the year with the consistent objective that the student would participate in the lesson in a way that is meaningful and purposeful, and of course, increase knowledge. In the case of administrators, the objective of implementing adaptations with teachers would again, be a process of active participation that would lead to increased knowledge of working with exceptional populations.

Time is of the essence. Just as teachers provide adaptations for students on daily lessons, administrators can also implement adaptations for the teachers with the same outcome of reducing them over the school year. One adaptation that a teacher may implement for students with auditory or visual processing issues, is to allow them additional time beyond that suggested in the unit to increase the likelihood that the child will comprehend the material. For administrators, it is essential to allow teachers time during the instructional day so that they can determine the most effective adaptations to consider given the pacing of the curriculum per unit, strand and lesson. By providing teachers with more time to collaborate with the special education support staff or other teachers who work with the same students increases the likelihood that teachers can implement the most effective adaptations.

Many children lose track of time and may find it difficult to maintain a teacher's instructional pace. By providing the student with an advanced organizer of the tasks that will be completed during a math lesson as well as the time devoted to each component of the lesson, the student will be able to know what activities will occur during that time and have two methods to reference time. In addition, the teacher can announce the amount of time remaining in a given activity. This announcement can be individualized, i.e. going near the student at 1 or 2 minute intervals during a class activity to provide a visual prompt as well as monitor and adjust as needed given the student's progress on the task.

This strategy can be used by administrators as well. Given the importance of the standardized assessments, providing teachers with an advanced organizer of expectations related to outcomes is essential (e.g. previous performance of students with exceptionalities, students exempt from components of the assessment, general adaptations that would be used for multiple students with exceptionalities). By having access to the structure of the assessment months in advance of the test will allow teachers to determine how to imbed and reinforce essential math skills.

Maximizing use of supports. In preparation for a lesson, teachers can break down the use of adaptations that are general to the class and those that are specific to an individual student or students. Each lesson has whole class, partner and independent activities. Teachers can identify what adaptations could be implemented given these three types of activities. In most cases fewer adaptations are more effective than more. For example, providing a handout of the multiplication facts as well as an ongoing list of the vocabulary can be used not only for a single unit but throughout the school year. Given the temporary nature of adaptations, students can assist the teacher in determining when a given adaptation is no longer needed.

Determining what strategies would be most effective in supporting teachers' mathematics knowledge and pedagogy while they are instructing exceptional populations often offers uniform solutions. Such solutions include an inservice or ongoing support using online collaborations with other teachers not only in the school building but across districts or states. But an alternative often under-used strategy exists. Pair the expertise of working with exceptional students with the content expertise of the classroom teacher. This collaboration is by far the best strategy for transforming the mathematics experiences for these students.

Timing, implemented from both a top down and bottom up perspective is one simple adaptation to consider. Planning what adaptations are needed given the instructional context is another. Teaming the classroom teacher with the special education teacher for mathematics instruction provides dual expertise. The consequences of not providing teaming, timing, and planning far outweigh implementing these strategies which will increase the likelihood of complying not only to NCTM standards but more importantly, the effective instruction of *all* students — including exceptional students!

Reference

Janney, R., & Snell, M.,(2000) *Modifying schoolwork: Teachers guide to inclusive practices.* Baltimore, MD: Brookes Publishing.

Fidelity and Adaptation of Professional Development Materials: *Can They Co-Exist?*

Nanette Seago, WestEd

ABSTRACT:

This paper investigates the relationship between fidelity and adaptation. It is intended for both professional development materials consumers and developers. We will identify the core principles of a set of well-specified professional development materials — Learning and Teaching Linear Functions — and use these to illustrate our argument about the relationship between fidelity and adaptation. We will propose a continuum of adaptation practices, from fatal to productive, maintaining that productive adaptations are ones that are consonant with underlying values and, in that way, expressions of fidelity. By explicating this continuum of adaptation practices and by playing out various scenarios where adaptation is called for, we attempt to shed light on how well specified core principles within professional development materials can provide access and opportunity for productive adaptations by facilitators.[1]

There is often a gap between what authors of professional development materials intended to happen with their materials and what actually happens when used by others (LeFevre, 2004). The resulting inconsistency often gets blamed on the facilitator for not using the materials as "intended" — adapting them in ways that corrupt the goals of the authors. It may not be that simple — the reality is that all materials require some adaptation, but how does one do so in alignment with the authors' intentions? Hilda Borko encourages us as a field to study "whether the materials and resources provided by programs are sufficient to ensure that multiple users in diverse settings can maintain integrity with the designer's intentions". She recognizes that:

> "Designers of these programs as they attempt to scale up, will inevitably face the dilemma that policymakers face: On the one hand, mutual adaptation to the needs and conditions of local sites is essential if a program is to be implemented effectively; on the other hand, too much adaptation can mean that the overall intent of the program is lost." (Borko, 2004, pgs 12-13)

The purpose of this paper is to explicate the meaning of and relationship between fidelity and adaptation. The notion of fidelity will be illustrated by describing the core principles of one set of well-specified professional development materials — The Video Cases for Mathematics Professional Development: *Learning and Teaching Linear Functions* materials[2] (LTLF). These core principles will be used to demonstrate the relationship between fidelity and adaptation. In addition, a continuum of adaptation practices will be proposed — from fatal to productive, maintaining that productive adaptations are ones that are consonant with underlying values and, therefore expressions of fidelity. By explicating this continuum of adaptation practices and by playing out various scenarios where adaptation is called for, this paper will attempt to shed light on the design features and values that are most important to the LTLF materials in particular, and potentially to well-specified professional development materials in general.

[1] I am grateful to Barbara Miller and Judith Mumme for their insightful comments and suggestions to this paper

[2] Supported by the NSF project ESI-9731339

Fidelity and Adaptation

from contextually embedded communication, wherein Fidelity means acting in accord with the core principals explicated in the professional development materials. Adaptation means not using the materials strictly as written/scripted (Borko,2004, LeFevre, 2004). In adapting materials, some actions are consistent with the underlying values and others are not. More typically, fidelity and adaptation are defined in opposition to each other and get cast in overly simplistic and dichotomous notions of good or bad. This is quite often determined by one's role — as a curriculum developer, fidelity is a good thing and adaptation is perceived as inherently bad. Professional developers may be more likely to put a premium on creativity and attention to context that is only possible with adaptation and curriculum developers may want their curriculum followed as close to as written as possible. Regardless of one's role or view, we believe that adaptation is inevitable because it means to take seriously the context (i.e., setting, participants, facilitator) in which materials are used. Adaptation and fidelity can not only co-exist, but also exist productively when two critical conditions are present:

(1) When the materials are well specified.

(2) When adaptations are consistent with the underlying design and values of the professional development materials.

Well-Specified Materials

Borko reminds us that as designers of professional development programs attempt to scale up, they will inevitably face a dilemma — "on the one hand, mutual adaptation to the needs and conditions of local sites is essential if a program is to be implemented effectively; on the other hand, too much adaptation can mean that the overall intent of the program is lost" (Borko, 2004). In order to deal with this inevitable dilemma, designers of professional development materials need to explicitly state their underlying core values and principles so that facilitators have the opportunity to adapt their materials with fidelity. Without access to the materials' core principles, a facilitator only has access to the script (e.g, the proposed agendas, the series of activities, etc.). This is analogous to only having access to the student edition of classroom materials. A teacher in this case would not have access to additional information a teachers' guide might offer such as: overall unit and lesson goals, content explication, connections to other units, pacing charts, teaching tips, etc. Quite often adaptations go awry because there is no resource for making decisions in accordance with the authors' intentions. The user is left to navigate in the dark without a sense of direction or guidance.

Well-specified materials make it possible to use materials with fidelity because they explicitly communicate the underlying principles. They clearly lay out the core principles for use of the materials and a rationale for why the authors believe these are important. They often make explicit the facilitator demands of the materials and include clearly laid out tasks. In addition, the tasks and facilitation demands have been articulated with an eye toward making the design and values explicit. The well-specified nature of the materials make it *possible*, not *probable* for users to adapt with fidelity. Written specification of underlying principles does not necessarily mean that readers will interpret them with the same understanding as the authors intended, or that they will choose to use them (even if they understand them) in making adaptation decisions. But, we do argue that the written specification does create an opportunity to do so — without which makes adaptation with fidelity nearly impossible.

Learning and Teaching Linear Functions: Video Cases for Mathematics Professional Development (LTLF)

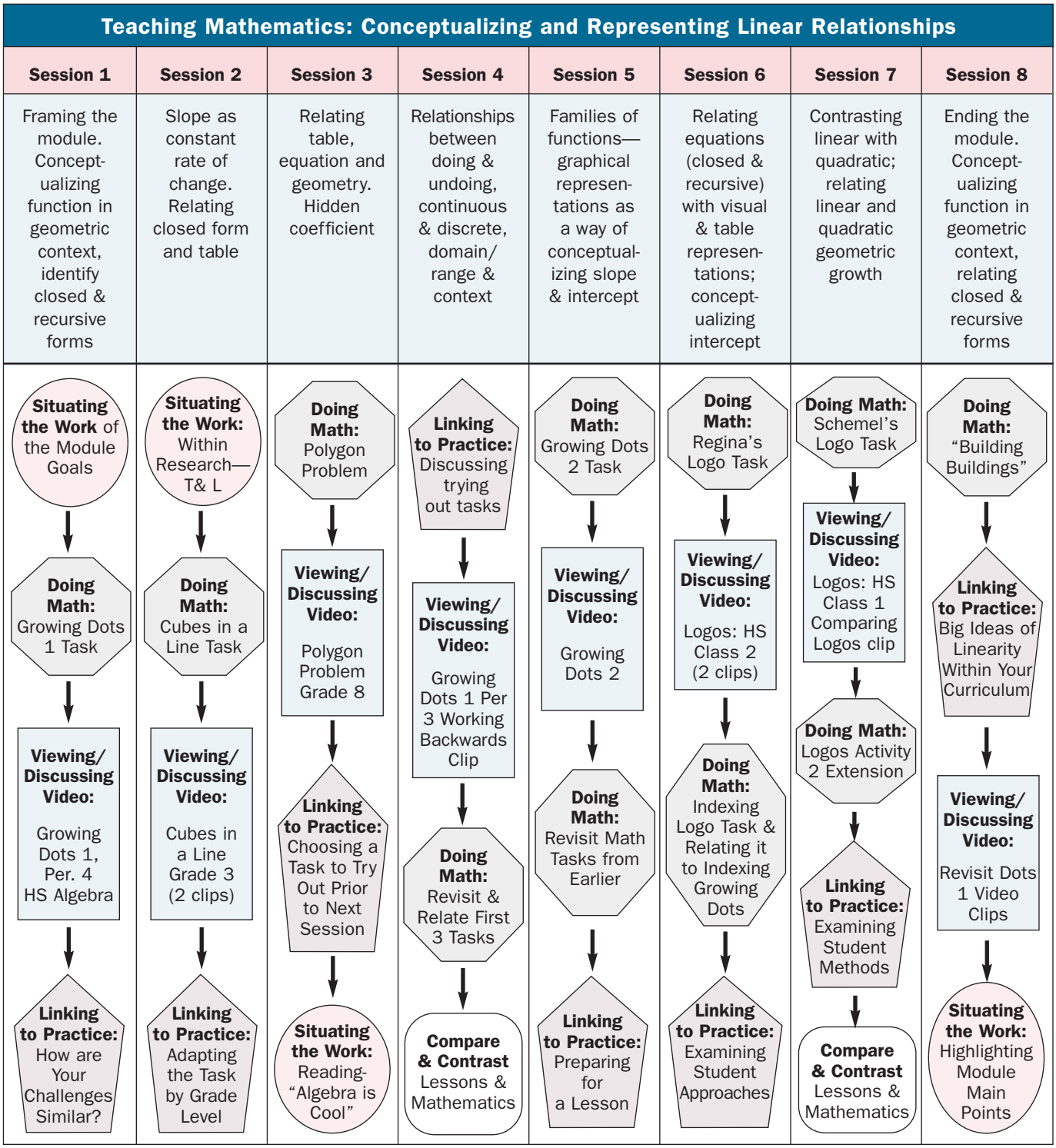
As a set of well-specified materials, the *Learning and Teaching Linear Functions materials*[3] are designed to help teachers deepen their understanding of mathematics content, students' mathematical thinking, and instructional strategies; as well as develop norms and practices for learning about teaching. The first of five modules, *Conceptualizing and Representing Linear Relationships,* is a sequential series of eight 3-hour sessions that are designed to enrich teachers' ability to teach linear relationships and deepen their own detailed knowledge of the distinctions and linkages among the various representations. Each session has at its core one or two digital video clips of a mathematics classroom. These clips are segments selected from real classroom footage of un-staged mathematics lessons, representing a range of grade levels, geographic locations and student populations. Each session is considered

[3] The Learning and Teaching Linear Functions materials are published by Heinemann at http://books.heinemann.com/products/E00682.aspx

a video case with the video episode as its centerpiece and includes four basic elements: situating the work, doing mathematics, viewing and discussing video, and linking to practice. The module map below helps to illustrate the activity flow of the module's eight sessions (figure 1).

The facilitation guide offers explicit and well-specified support for using the materials with fidelity. It includes such information as: a complete overview of the materials, explanations and rationale of the underlying principles and specific goals, sample agendas and guidelines for

FIGURE 1



sessions, lists of references and useful resources, tips for facilitation including caution points, mathematics commentaries and excerpts from a composite facilitator's journal chronicling the experiences of others having used these materials. These materials are carefully designed, multi-layered, cohesive modules of professional development curricula. Ball and Bass highlight the contribution these materials offer to the field.[4] Specifically, they note the support they provide for use by facilitators, "They provide practice-based resources for study and analysis, and they provide guidance and insight to the teacher developer using the materials."

Underlying Principles and Values of the LTLF Materials

In order to use these materials with fidelity, facilitators need to understand and honor the explicated three core principles of the materials: (1) serious and intentional use of video as a carefully chosen medium; (2) serious and intentional use of the mathematical work within the materials; and (3) respect for both the curricular nature of the materials and teachers as learners. Each of these three principles is further explicated below:

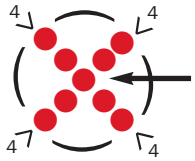
I. *Serious and intentional use of video.* These materials are designed around video as the medium. Since video is central to the intentions of the materials, in order to analyze the interactive nature of mathematics teaching and learning, NOT using the video would be a breach of values. Besides using the video, in order for facilitators to use these materials effectively in orchestrating discussion and probing teacher thinking, a deep understanding of what is inside each video clip is also needed. For example, the first session of the foundation module includes the following video clip:

Kirk, a 9th grade Algebra teacher, poses the following task to his students with the goal of helping them visualize and conceptualize slope and y-intercept:

Study the sequence of dots. Describe the pattern you see. Assuming the sequence continues in the same way, how many dots are there at 100 minutes? Find an equation for the number of dots at *t* minutes.

After working on the problem for a few minutes, Kirk brings the class together to discuss their solution methods. Danielle shares her answer of x • 4 + 1 *and Kirk asks her to illustrate how she connected her expression to the dots at the board. When Kirk asks for a different method, James shares his method.*

x • 4 + 1 **Danielle**



The center or 1 in the equation 4 should be all the dots except in the center. X is how many dots out from the center.

James x + 4

X is the previous picture. That plus 4 is the next picture.

1 + 4 = 5

[4] Ball, D.L. & Bass, H. (2004), Foreword in Learning and teaching linear functions. Portsmouth, NH: Heinemann.

First of all, the facilitator needs to show the video and give ample time for analyzing and discussing it. Within this segment, the demands on a facilitator are many. A facilitator needs to recognize that both James and Danielle's methods are made public and potentially available for collective use by the whole class when they are asked by Kirk to come to the board and share their solution and method. They need to understand what each student method entails. They need to recognize the complexity and challenge in teaching students to represent, communicate and present their ideas during a whole class discussion. In addition to all of this, they need to predict and plan for how their teachers will respond to this segment and the ideas embedded in it and figure out how to increase their opportunities to learn the curricular trajectory of the materials. Although the materials provide support for developing these understandings, in order for a facilitator to gain these skills they would need to view for themselves the video clips multiple times, read over the commentaries and notes, figuring out the mathematical points, project how teachers may respond to the video clip, and prepare how to use the clips with their teachers.

II. *Serious and intentional use of the mathematical work within the materials.* As with the video, the mathematical work is an important feature of these materials and to NOT do it would be counter to the principles. But doing the mathematical tasks is not sufficient, facilitators of these materials should possess the ability to "decompress" mathematical ideas, particularly when such ideas appear to be straightforward mathematics. A facilitator would need to prepare for the mathematical content — both what is taught and what is embedded in the teaching of that content. Using the video clip example above to illustrate this point, a facilitator would need to know that James is using a recursive, iterative approach to finding the number of dots (noticing that you add four each time to the previous number of dots) and Danielle is using an explicit approach, looking at the relationship between the number of dots and the number of minutes. They would also need to understand that each is using the variable "x" to represent something different. While James is using x to represent the previous number of dots, Danielle is using the x to represent number of groups of four [though it is unclear what the 4's represent in her drawing and which group of fours she is talking about — the number of dots in each of the four "arms" of the picture or the number of groups of four dots "out from the center", or a combination of the two methods]. A facilitator of this case must also be able to recognize various approaches and methods beyond these two approaches, distinguish amongst them, and find correspondences between them. Likewise, in supporting teachers to conceptualize and represent slope and y-intercept, a facilitator must be able to sift through the fine grain details involved within these two seemingly straightforward elements of linear functions and unearth potential underlying conceptions and misconceptions. Again, the materials provide support for the development of these capacities, a facilitator would need to examine the student methods carefully, analyze the mathematical logic of each, and study the mathematical explanations and resources of the materials.

III. *Respect for both the curricular nature of the materials and teachers as learners.* Facilitators need to have a clear sense of the learning trajectory of the materials, their cohesive, scaffolded design and would need to use them as a curriculum, not a menu of activities. They would need to respect teachers as learners and a hone their ability to observe and assess the teachers in relationship to the curricular goals. This means that they would need to adapt the materials to fit the needs of their teachers, while at the same time respecting the curricular nature of the materials. For example, teacher participants are often unfamiliar with the thinking involved within recursive approaches to problems, having previously assumed that such solutions as James were simply incorrect. A facilitator would need to understand that as teachers explore the mathematical logic behind a recursive approach and its relationship to explicit strategies across multiple video case sessions, the opportunity exists for them to develop a deeper understanding of the distinction between and the relationship amongst recursive and explicit forms of linear relationships in particular and linear functions in general. Understanding that these ideas will emerge in multiple sessions in various ways, can ease the burden that facilitators often face in trying to cover everything in one session. In order for facilitators to gain this understanding, they would need to spend time examining the entire module and its cohesive, scaffolded design, so they have a sense of how it fits together. In addition, they would need to examine what each session brings in light of the overall goals.

In order to honor and respect the participants, the facilitator will need to spend time listening carefully to their teachers.

The Relationship between Adaptation and Fidelity

It is assumed that all facilitators make adaptations. Furthermore, it is assumed that not all adaptations are productive ones, nor are they of the same magnitude. In order to examine the various types of adaptations a facilitator might make, categories of adaptation along a continuum scale can help reveal use with fidelity. This scale has a range from fatal adaptations at one extreme to productive adaptations at the other, while in the middle lies the types of adaptations that do not impact the design of the materials negatively or positively.

CATEGORIES OF ADAPTATION

As the scale illustrates, there are various types of adaptation. The levels on the scale are not meant to imply discrete stages of use — a person could use part of the materials productively and part of them fatally. The scale is not intended to represent a linear progression from one stage to the next — a person could begin adaptation fatally but gain knowledge and jump to productive use, or a person could begin with "no impact" adaptations and make a "fatal" adaptation down the road. The scale is intended to suggest categories of adaptation by facilitators in using the materials. The scale represents a relationship between fatal and productive adaptations in terms of underlying values — a fatal adaptation reflects no fidelity to underlying values, and a productive adaptation reflects a great deal of fidelity to underlying values. It is assumed that "fatal" adaptations are not made intentionally. That is, they are not intended to be unproductive — but it can happen nevertheless. Fatal adaptations can be a result of facilitators choosing to do something contrary to the underlying principles or they can be a result of the fact that a facilitator had no access to the underlying values. Decisions to change things have consequences in relation to the underlying principles and values of the designed materials. At the two extremes, a fatal adaptation would be one that is in direct opposition to the underlying values and a productive adaptation would be one that is in concert with them. Indeed, no adaptation at all can also be problematic. Mechanical, scripted use of the materials to the point of an over-reliance on only what is contained in the written guides — the belief that if I as a facilitator, *use the materials exactly as written, with no adaptations, then I'll be effective* — is not using these materials as designed, since adapting the materials to participants is an explicit and critical component of effective use (an underlying value).

The three-point scale along a continuum described below:

I. *Fatal Adaptations.* Some adaptations create severe problems and reveal misconceptions of facilitators about the intended use of the PD materials. These adaptations can be considered fatal errors and seriously undermine critical components of the materials. Because they are contrary to the basic design or values of the materials, we categorize these adaptations as fatal.

II. *No Impact Adaptations.* Some adaptations are possible, and seem relatively neutral in that they don't have a big impact on use with fidelity. These "no harm, no foul" adaptations are categorized as no impact because they don't undermine the basic design or values of the materials, nor do they make the best use of them.

III. *Productive Adaptations.* Some adaptations by facilitators are productive in that they make the best use of the materials given the circumstances in which they are working. Adaptations are made that relate to particular participants in particular contexts, while at the same time keep an eye on the learning trajectory of the materials. Because the changes that are made are consistent with the design and underlying values, we categorize these adaptations as productive. In our view, thoughtful use of LTLF materials should involve productive adaptation.

The Nature of Adaptation

The LTLF materials will be used in this section of the paper as an example to consider the nature of adaptation. Two common cases of use will be described that require adaptations by a facilitator: 1) not enough time and 2) participants with limited content knowledge. Within each case are examples of No Impact, Productive and Fatal adaptations in order to highlight what is meant by these varying degrees of use with fidelity.

CASE 1: NOT ENOUGH TIME

Time is limited for professional development and facilitators are often faced with decisions about adapting materials to fit a set of time constraints. While the foundation module of the LTLF materials is designed for eight, three-hour sessions, many situations simply cannot accommodate this — district constraints for the number of after school sessions, or a need to utilize a district's designated professional development days. This situation requires adaptations to be made. These adaptations can impact use with fidelity. We explicate three categories below, beginning with no impact and then moving to fatal and productive impacts.

No Impact: No Impact adaptations are essentially such insignificant adaptations that they don't matter — they don't really change the experience. No impact on use with fidelity in the case of the LTLF materials could include a facilitator's decision to:

- Combine two, three-hour sessions into one full day professional development offering. This has no impact because the number of sessions stays the same and is aligned with the design and values of these materials.
- Cut the sessions to two and a half hours — eliminating the formal break and individual time for work on the mathematics. This decision only has no impact if the participants are given the math task prior to the session so that they have a chance to work on it.

Fatal: Fatal adaptations are changes made with little or no fidelity to the intent or the underlying ideas in the materials. Adaptations that would be considered fatal errors in relationship in using the LTLF materials, can include such facilitator decisions to:

- Eliminate crucial components within a session (e.g., eliminate all video or cut short the work on the mathematics). This adaptation is fatal because it is contrary to the design of the materials — leaving out any crucial element such as video or the mathematical work would severely limit the potential effective use of the materials.
- Eliminate full sessions. This adaptation is fatal because these particular materials were designed as a series of connected professional development experiences. By eliminating full sessions, the materials are not being used with fidelity to the underlying values because teachers might miss important ideas and because the sequence builds upon one another.

Productive: Productive adaptations are changes made with fidelity to the intent or underlying principles. Adaptations that would be considered productive in relationship to intended use of the VC materials include such facilitator decisions such as:

- Combine consecutive sessions that cohere well in a full day session. This adaptation takes seriously the mathematical flow and purposeful order of the materials and highlights the links between particular sessions. In this way, the adaptation is productive and in alignment with the underlying values of the materials.
- Re-design a full day session to think carefully about participant's energy level (e.g., more in morning than after lunch). This adaptation takes seriously the participants as well as the design of the sessions and module. It requires both knowledge of the materials and the participants and is therefore consistent with the underlying principles and values.
- Design for partial online work in order to shorten face-to-face time, without compromising overall time. This adaptation can be productive if the nature of the online work is consistent with the underlying values of the materials such as: online discussions of linking to practice activities, comparative analysis across sessions, or mathematical work. This ensures consistency with the values in that the work is still part of the work, only in an online venue.

CASE 2: PARTICIPANTS HAVE LIMITED CONTENT KNOWLEDGE

A common situation that facilitators of professional development face is the issue of their participants limited content knowledge. In order to be responsive to their participants needs, this situation demands adaptations of the LTLF materials. These adaptations can result in varying degrees of use with fidelity. We explicate three categories below, beginning with no impact and then moving to fatal and productive adaptations.

No Impact: No impact on intended use (use with fidelity) in the case of the LTLF materials could include a facilitator's decision to:

- Reorder activities to focus first on linking to practice. This is characterized as "no impact" since the activities reordered (linking to practice, see figure 1) do not change the underlying design and values. However, if a decision was made to reorder the mathematical work and video work, this would be contrary to the design

and values of the materials because it changes the opportunity to examine the mathematics prior to focusing in on the video episode (an explicit design decision and underlying value).

- If there is a need to concentrate on a few key concepts deeply, provide additional mathematical experiences that may include combining consecutive sessions that focus on a few particular mathematical purposes. This has no impact because attending to participants needs and furthering key mathematical conceptual learning are both aligned with the design and values of these materials.

Fatal: Adaptations that would be considered fatal in relationship to fidelity if they are contrary to the design and values of the materials. These fatal adaptations can include such facilitator decisions to:

- Accept unquestioningly whatever participants say or produce as good and accurate, in the spirit of trying to affirm their efforts but not identifying their limited knowledge. This adaptation is fatal because it is not consistent with the mathematical learning goals of the designed materials.
- Rely solely on the idea that participants will figure this out on their own eventually, without facilitator assistance via synthesis, reflection, or explication of participants' ideas or even by direct instruction (though by design, not right away). This adaptation is fatal because it is contrary to the underlying value that facilitators are teachers who can and should play an active role in supporting teacher learning.
- Use a lecture mode in the first session to bolster limited content knowledge, aiming to teach participants certain concepts ("here's what recursive means") and thereby violating the spiraling design of the curriculum during a first encounter with a concept.[5]

Productive: Adaptations that would be considered productive in relationship to fidelity of LTLF materials' use, include such facilitator decisions such as:

- Strategic choice of using participant work or explanations (lifting up and highlighting) to direct participants' attention to particular content knowledge (e.g., facilitator's choice about when to introduce term "recursive" and what work/comments from the participants work to link the term to). This is a adaptation that is consistent with the underlying design and values of the materials in that it takes seriously both the mathematical learning goals of the curricula and the participants ideas.
- Aim for mathematical ideas that are more familiar and more accessible (e.g., rate of change versus formalizing ideas related to recursion) and relate the more accessible concepts to more abstract concepts. This is productive in that the adaptation attempts to better address the learners' needs by creating mathematical accessibility without compromising the key mathematical learning goals.
- Make more extensive use of visual representations and meanings ascribed to them (e.g., labeling). This adaptation is productive in that it is consistent with the design and underlying values around content and learners. This adaptation recognizes that often participants with limited content knowledge are more likely to produce or understand visual representations that keep their emerging understanding of the concept intact.
- Use the video to revisit the mathematics. This adaptation is productive in that it is using student ideas within the video to raise additional work on the mathematics, thereby creating opportunities to deepen and expand the mathematical learning of the participants.

Conclusion

This paper has put forth the notion that fidelity and adaptation can not only co-exist, but also work together productively. In using the Learning and Teaching Linear Functions materials to illustrate the argument about the continuum of adaptation practices, from fatal to productive, it was argued that productive adaptations are ones that are consonant with underlying values and are therefore expressions of fidelity. By playing out various scenarios where adaptation is called for, the intention of this paper was to shed light on how well specified professional development materials can provide facilitators access and opportunity for adaptations to make adaptations with fidelity.

These categories of adaptations can not only apply to issues of use with fidelity within these particular materials, but potentially apply to other well-specified materials as well. While the specifics of what counts as fatal or productive may vary, the fact that one could use a well specified set of materials consistent with or contrary to its underlying

[5] This is not to suggest that a facilitator never tells, rather timing and purpose make a difference in how ready learners might be to attach the meaning of what is being told. [Lobato, et.al, 2005)

design principles and values generalizes beyond the LTLF materials. It seems logical that adaptation of other well-specified professional development materials[6] could also be categorized from fatal to productive, depending upon how those adaptations line up with the authors' underlying values and design principles.

In general, developers of PD materials could support use with fidelity by ensuring that they specify their underlying principles and intentions explicitly enough that users can make informed decisions about productive adaptations. Likewise, users of PD materials could look for (and demand) PD materials that are well specified, thereby allowing them a window into the authors' intentions and creating the opportunity for them to make informed decisions about their adaptations.

In addition to PD developers and users responsibilities, research can play a role in furthering the knowledge about the relationship between fidelity and adaptation. Borko encourages us as a field to investigate the relationship between fidelity and adaptation across multiple settings, in order to consider which elements of a program must be preserved to ensure the adaptations aligned to underlying goals and principles. Even though examining one set of materials is useful, it is clearly not enough. We need studies across multiple programs to examine questions such as: *Do well-specified materials yield more likelihood of adaptation with fidelity? Or, what resources support productive adaptation?* We as a field could also gain in knowledge if we studied whether these proposed scales of adaptation cut across multiple and varied programs and/or disciplines, e.g. *Can fatal to productive adaptations can be understood in professional development materials in science?* Clearly much investigation is ahead of us. Hopefully this paper has opened the door to possible conversations, new thinking and future research.

References

Barnett, C., Goldenstein, D., & Jackson, B. (Eds.) (1994). *Decimals, ratios, and percents: Hard to teach and hard to learn?* Portsmouth, NH: Heinemann.

Borko, H. (2004) Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, Volume 33, Number 8, pp. 3-15.

Driscoll, M.D., Zawojewski, J., Humez, A., Nikula, J., Goldsmith, L., Hammerman, J. (2001). Fostering algebraic thinking toolkit. Portsmouth, NH: Heinemann.

Franke, M.L., Carpenter, T.P., Levi, L., & Fennema, E. (2001). Capturing teachers' generative change: A follow-up study of professional development in mathematics. *American Educational Research Journal.* 38(3), 653-689/

Lampert, M., Ball, D.L. (1998). *Teaching, Multimedia, and Mathematics: Investigations of Real Practice.* New York: Teachers College Press.

Lappan, G. & Phillip, B. (1998). Teaching and Learning in the Connected Mathematics Project, Chapter 14, *Mathematics in the Middle*, NCTM and NMSA.

LeFevre, D.M. (2004). Designing for teacher learning: video-based curriculum design. In J. Brophy (Ed.), U*sing video in teacher education: Advances in research on teaching* (Vol. 10, 235-258). London, UK: Elsevier, Ltd.

[6] e.g. as Developing Mathematical Ideas (Schifter, et al 1999), Fostering Algebraic Thinking Toolkit (Driscoll, et. al 2001) , and Using Cases to Transform Mathematics Teaching and Learning (Smith et al, 2005) materials

Lobato, Joanne, Clarke, D., Ellis, A. (2005) Initiating and electing in teaching: a reformulation of telling. Journal for Research in Mathematics Education. 36(2), 101-136.

Schifter, D., Bastable, V., Russell, S.J., Lester, J.B., Davenport, L.R., Yaffee, L., & Cohen, S. (1999a). *Building a system of tens.* Parsippany, NJ: Dale Seymour.

Schifter, D., Bastable, V., Russell, S.J., Lester, J.B., Davenport, L.R., Yaffee, L., & Cohen, S. (1999b). *Making meaning for operations.* Parsippany, NJ: Dale Seymour.

Seago, N., Mumme, J., & Branca, N. (2004). *Learning and teaching linear functions.* Portsmouth, NH: Heinemann.

Seago, N. (2004). Using video as an object of inquiry for mathematics teaching and learning. In J. Brophy (Ed.) *Using video in teacher education: Advances in Research on Teaching, Volume 10* (pp. 259-286). Orlando, FL: Elsevier, LTD.

Smith, M. (2001). National Council of Teachers of Mathematics, Inc. Reston, VA.

Stein, M.K., Smith, M.S., & Silver, E. A. (2000). *Implementing standards-based mathematics instruction.* New York, NY: Teachers College Press.

Stein, M.K., Smith, M.S., & Silver, E. A. (2005). *Using cases to transform mathematics teaching and learning*, Volumes 1, 2, 3. New York, NY: Teachers College Press.

Wilson, S. M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. In A. Iran-Nejad & P. D. Pearson (Eds.), *Review of Research in Education* (Vol. 24, pp. 173-210). Washington, DC: American Educational Research Association.

Wilson, S. M., Floden, R. E., & Ferrini-Mundy, J. (2001). *Teacher preparation research: Current knowledge, gaps, and recommendations.* Seattle, WA: Center for the Study of Teaching and Policy, University of Washington.

Building Coaching Capacity Through Lesson Study

Lucy West, Metamorphosis Teaching Learning Communities
Ginger Hanlon, Phyllis Tam, and Milo Novelo, Region 9, New York City Public Schools

It seems that policy-makers and administrators are convinced that professional development is the key to student achievement and that content coaching is an effective method of professional development. In their haste to get coaching into schools, districts often do not build the necessary foundation that will insure coaches' success — criteria for which also remains undefined. There is no consensus about the role and responsibilities of coaches or how best to utilize them. (We are using the term coach broadly to mean any job title that includes assisting teachers with improving math instruction as part of their responsibilities. Though principals may do some coaching, we are not thinking of principals as coaches for this article.) For example, New York City, San Diego, Los Angeles, Baltimore, and other large urban districts hired large numbers of instructional coaches at some point in time over the past few years in an effort to upgrade instruction and improve student achievement. The resulting dilemma in these cities was that a host of people with varying points of view about math education, little or no coaching experience, varying degrees of familiarity with local curriculum materials, were disseminated among schools with little direction or clarity. They were assigned to schools with very different contexts and cultures and in which there was little precedent for effectively employing instructional coaches.

In general, both in New York City and across the country, coaches were teachers, teacher leaders, math coordinators or department chairs last year and "coaches" this year. In our experience, we have observed the following:

- The role and skill set of coaches is rarely defined in the early stages, and is different from coordinator, department chair or classroom teacher
- First year coaches often have difficulty making the transition from their old job description to their new amorphous role
- Unskilled coaches are often dropped into a culture that is nebulous about the purpose of coaches and what coaches are supposed to know and be able to do
- Coaches rarely receive ample training, support, or direction
- Coaches tend to be extremely isolated from one another thus coaching is even more idiosyncratic than teaching
- Coaches are rarely part of a team that has a clear mission, change theory and coherent strategy
- Coaches are rarely fully embraced members of the school communities to which they are assigned.

These are the circumstances we found ourselves facing in New York City's Region 9 in 2003. Our challenge was to build a competent coaching force with a coherent vision and skill set to improve mathematics instruction across 179 schools K-12 as quickly as possible. This article examines one possible and powerful vehicle that may address the issue of "on the job " coach development — lesson study. We posit that districts need to build into coaches' schedules the processes, models, and scaffolding needed for cultivating the capacities and expertise of coaches. Effective content coaching that results in improved instruction and learning involves, among other things, skillful lesson and unit planning among professionals focused on learning — theirs and their students. In other words, one of the main tasks of coaches is to assist teachers to deepen and refine their lesson designs and gather evidence of student understanding or lack thereof. Lesson Study is a model for thoughtful, collaborative lesson design and analysis. This work is at

the heart of content coaching. Our hypothesis is that by engaging coaches in the process of lesson study we can help them develop part of the skill set necessary for effective content coaching and build a coherent understanding of the kinds of instructional practices worth disseminating across a district.

What we have learned, in Region 9 and in work across the country, is that it is the role of the district to provide supportive structures and processes to allow coaches to develop the skill set necessary to be successful. Coaches are poised to become catalysts for building or upgrading the level of professional learning communities within and across schools. (West 2005) Our concern is that coaching, which holds enormous potential for the profession, will go the way of so many initiatives without more thoughtfully, strategically and systematically cultivated development.

What do we mean by lesson study?

The work described in this article is based on what the authors understand about Japanese lesson study and their experiments with Americanized versions of the process. We are not advocating a strict adherence to the formal Japanese model and have taken many liberties with it.

Lesson study in our view is a process that has the following characteristics:

- Involves a group of professionals collaboratively planning a lesson or series of lessons based on some common goals or questions or set of principles.
- Is inquiry based and focuses on student learning. A group of professionals study a common goal or question and assess how the goal progresses by clinically examining their own practice in light of evidence of students' learning.
- Utilizes curriculum materials that are available or adopted by the district. The curriculum materials are seen as tools and the lessons described in these materials are the starting point for building specific lesson plans appropriate for students.
- Includes the engagement of participants in actually "doing the math" contained within the lesson being planned.
- Provides the participants with common tools for planning the lesson. In our case, we used some version of The Guide to Core Issues in Lesson Design, (West and Staub, 2003). (see Figure 1)
- Involves the public teaching of the planned lesson by one of the participants. The planning team and other invited guests observe the lesson.
- Involves focused observation by planning team and guests based on an observation guide or an issue for which the planning team wishes to gather data or evidence.
- Includes a formal debriefing of the lesson using an agreed upon protocol with the assistance of a skilled facilitator.
- Is an iterative process in which the lesson is refined, retaught and debriefed a second time.
- Ideally, happens on a fairly regular basis over the course of a year or several years
- Requires that at least one person present deeply and flexibly understands the mathematics under discussion.

Framing the Context

In the new structure implemented in New York City in July 2003, community school districts with diverse needs, resources and beliefs about teaching and learning were joined into regions. As part of the reorganization, the city created "coach" positions, with the intent that each of its 1200 plus schools would have both a math and literacy coach to support teachers in improving instruction. The new position was announced in late spring and the hiring was expected to commence over the summer and coaches assigned to schools by September. The role was being invented as the hiring was taking place. Region 9 hired 70 math coaches, less than half the number of coaches the city intended. Within the Region 9 group of coaches there was a wide range of skills and perspectives on teaching and learning. Many of the coaches hired were not familiar with the new curricula, nor were they familiar with lesson study and content-focused coaching (except for the few that were former teacher leaders and coaches in Community School District 2).

Region 9 has about 179 schools K-12 and includes much of Manhattan and part of the South Bronx. It contains the former Community School Districts (CSD) 1, 2, (a district known nationally for its innovative and effective professional development) 4 and 7. Of the four CSD within Region 9, District 2 was the only district to have a coaching model in place prior to reorganization. Content-focused coaching, a research based instructional coaching model, was developed by Lucy West and Fritz Staub in CSD 2,

FIGURE 1

Name of Study Lesson: **Grade Level:**

What is the math in this lesson?

- What is overall goal?
- What are specific concepts?
- Are there specific strategies to be developed?
- What skills are addressed?

Focus on Students:

- What relevant concepts have already been explored by the class?
- What strategies does this lesson build on?
- What familiar or relevant contexts could you draw on in relation to this concept?
- How does this lesson engage students in thinking and activities that move toward the goals stated?
- What misconceptions or difficulties do you predict children may have?
- What support or interventions can you provide?
- In what ways can you provide extensions or challenges?

Implementation of Lesson:

- How will you introduce or present the problem/lesson?
- How will students be grouped and why?
- How will you make materials available to students?
- What models or visuals can you use?
- In what ways will students make their thinking and learning public?
- How will you insure that students are talking and listening to each other about important mathematics?
- How will insure that students can clarify, highlight and grapple with one another's ideas?

Reflection/Evaluation:

- What will evidence of children's understanding look and sound like?

Based on Content Focused Coaching *by Lucy West and Fritz Staub*

with the support of a teacher enhancement NSF grant and in conjunction with the Institute for Learning, University of Pittsburgh.

Under the direction of Lucy West, District 2 also had more than four years of experience utilizing some version of lesson study with teacher leaders K-12. District 2 had experimented with Collaboration Sites (West and Curcio) in the elementary schools and with lesson study in the middle and high schools. Collaboration Sites involved bringing teams of teachers to a school in which a few teachers, teacher leaders and coaches would open their classes to their colleagues from across the district. These sessions involved sharing the lesson plans prior to observation; having an observation focus; debriefing the lesson and analyzing student work after the lesson. Collaboration Sites resemble the "open house" aspects of traditional Lesson Study. (Lewis)

In our middle and high schools we worked with Clea Fernandez and Makota Yasshido from Columbia University's Lesson Study project for two years and designed lesson study that more closely resembled traditional Japanese Lesson study with our secondary teacher leaders and coaches. The work involved finding a "common goal" and gathering evidence of where we were in relation to that goal; collaborative lesson planning using the Connected Mathematics Project and Mathematics: Modeling Our World curriculum materials and then open house lessons that were debriefed, refined and retaught. We did two cycles of lesson study a year for each group of involved teacher leaders and coaches.

Returning to the case of Region 9, initial visits to schools, early coach meetings, and research (Stigler and Hiebert, 2004; Ball and Bass, 2000, 2004; Hill, Rowan & Ball, 2005; Lewis, Perry and Hurd, 2004), revealed some very common issues across the region in terms of mathematics teaching and learning. Foremost, on the part of some coaches (and many teachers), was a striking lack of conceptual understanding of the mathematics they teach and a parallel lack of knowledge of children's development of mathematical ideas. For example, elementary level coaches spent several sessions examining the properties of whole number operation, trying to understand operations as more than procedures. Without these two elements, coaches are greatly hindered in their ability to support classroom teachers in improving instruction and learning. Quite a few coaches (and many teachers) were not even aware that it is possible to truly engage with ideas in a math class, never having had the opportunity to do so themselves. Another issue was the discrepancies seen in the depth of lesson and unit planning by both coaches and teachers.

The authors discovered that lesson study could be a more appropriate professional learning vehicle initially for coaches and teacher leaders than for teachers at large. This finding is in line with Jim Stiegler's remarks at NCSM in 2005 in which he shared his experience that even when given substantial chunks of time to plan lessons in detail, American teachers often complete their planning process in about half an hour. They report that they do not know what else to consider in their designs. Without outside expertise, they do not know how to deepen and extend their thinking. This finding is in line with Elmore's conclusion that at different stages in a school improvement process it is necessary to infuse new information into the community. (Elmore) In many settings, educators have not had the professional learning opportunities that would develop the skill set needed to successfully engage in a fruitful lesson study and often work in contexts in which collaboration is not yet part of the culture. Lesson study has proven to be a useful process when there is enough skill and expertise in the circle of professionals engaging in the process. It is less successful when participants are unskilled in planning, have fragile knowledge of the content, are not prone to "kidwatching," have limited pedagogical repertoires and are not used to engaging in professional dialogue. Thus, if a cadre of coaches could be cultivated in any given district who develop the expertise to engage in productive lesson study, they, in turn, could begin to engage the teachers with whom they work in modified, site-based versions of lesson study, combined with coaching. This is one way to build professional learning communities focused on the instructional core processes of teaching and learning and sustain capacity over the long haul.

Professional Development Plan

Returning to our experience in Region 9, the professional development plan was designed to address the observed lack of a common basis for approaching the study of teaching and learning and issues of content and pedagogical knowledge. This plan was, in turn, informed by our experience in CSD 2 in which we had cultivated a cadre of sixteen skilled coaches and 75 teacher leaders over a period of five years.

One crucial element of the Region 9 plan was lesson study. The regional instructional team in math met with coaches twice a month for a half a day at the beginning of the year. Given the scope and scale of the work to be done, in December, the meetings became full day. At those meetings, much groundwork was laid for participation in lesson study. For example, coaches (and teachers) needed help in learning how to observe lessons. By incorporating coursework such as Developing Mathematical Ideas (EDC) and Fostering Algebraic Thinking (EDC) into the meetings, the regional team was able to engage the coaches in conversations around content, pedagogy and children's thinking and to hone observation skills. Coach meetings also provided opportunities for coaches to examine and analyze the curricula used in Region 9 schools and to learn about the format and goals of lesson study.

After the first round of lesson study in both elementary and secondary schools had taken place in Region 9, the regional instructional team saw the need for a conversation with all coaches, focused on the question: "What are the elements of a good lesson?" One of the difficulties in the first round was that in the planning and debriefing not enough attention was paid to the specific mathematical content in the lesson. We wanted to make explicit the connection of the processes of lesson study to their work as coaches. We wondered, "How can coaches take their experience in lesson study and use it in their work as coaches?" Focusing conversations on the specific mathematical content in the planning of lessons in schools is the job of the coach. That conversation was critical to develop a shared understanding of what we mean by "good" teaching and planning. In addition, the conversation was grounded by

the use of a common planning tool (see insert) which encourages more specificity and depth in defining mathematics content in terms of concepts, strategies and skills, than appears to be the habit of many of the coaches and teachers we've encountered. The planning tool is an adaptation of the work of Staub and West, A Guide to Core Issues in Lesson Design.

In Region 9, two cycles of lesson study at each level — elementary and secondary — were conducted as part of the professional development plan in year one. In the first cycle of lesson study, small groups of coaches, working with a lead coach experienced in lesson study, planned a study lesson. A key element of the planning, not generally practiced in Japanese lesson study, was that the coaches actually did the activity and analyzed the specific mathematics to be taught. This engagement in the mathematics led to discussions about key mathematical concepts and the web of ideas connected to the concept to be taught. These rich sessions allowed coaches to gain a broader knowledge of both the content and possible pedagogical strategies to help students learn that content.

The lead coaches then taught the lessons in classrooms in which they worked with teachers. The classroom teachers, along with other elementary and secondary coaches, were observers and participants in the debriefing and adjustment of the lesson. This gentle introduction convinced several newer coaches to take a lead role in lesson study in the second cycle. Observation provided coaches with opportunities to not only examine teaching but also student learning and engagement with mathematics at different grade levels. For example, one secondary coach, with some surprise, was particularly intrigued by the elementary lesson study he observed which focused on algebraic thinking using a "function machine." This experience demystified his preconceived notions about what mathematics is taught in elementary school.

In this first cycle of lesson study, both lessons took place in the same day, one in the morning and one in the afternoon, with an extended "working lunch" for debriefing and adjustment of the lesson. This design has both benefits and drawbacks. One benefit, which is extremely important in parts of the region where substitute teachers are hard to find, is that it is possible to reschedule the day to require little extra coverage. Having to do so for only one day instead of the customary two days minimizes the disruption to schedules of both participating teachers and their colleagues at other grade levels. It also minimizes the impact on other schools since observers are out for just one day. A drawback is that the time constraint allows only small changes to the lesson. The interesting thing is that teachers saw how even a small, thoughtful adjustment — in pacing, visuals, questioning or focus — could have a major influence on the effectiveness of the lesson.

We found it best to work with the adopted curricula materials as the foundation for study lessons rather than to write completely new lessons. By using published curriculum materials teachers and coaches recognize the relevance to what they do every day and it allows for a slightly more expeditious planning cycle. If teachers use the curriculum materials they generally work with as their starting place and work to refine and enhance the lessons based on what they know about the students in their class and the collective wisdom of the teaching community, the lessons are richer and more targeted (see planning guide). This is generally a new way of thinking and engaging with curriculum materials for the many teachers who see curriculum materials as a script to be followed. In fact, West and Staub take the position Content-Focused Coaching represents a profound change — from teaching as *mechanically implementing curriculum* to teaching as *mindfully making use of curriculum.* (p. 5)

How does lesson study help coaches become skillful agents of change?

Lesson study was a powerful experience for the coaches. Through their experience with lesson study, Region 9 coaches developed a deeper understanding of what is required to plan and teach a successful lesson. The success of the lesson was now determined by evidence of student outcomes and understanding, not by pacing, use of particular materials, use of technology or styles of teaching such as cooperative learning or other elements of a lesson. Lesson study practice among coaches (quotes are from reflections on lesson study by participants):

- **developed stronger planning habits,**

"Maybe the most important idea is the collaborative planning. It gives me a deeper sense of math which I can carry to the students."

"I've noticed that lesson study invites teachers to think deeply and intentionally about their choices."

• **deepened content and pedagogical knowledge**

"I made a big shift from teacher-centered teaching to learning how to question students so they come up with the ideas."

"I am relearning the math. The more we work with it and talk about it the more I discover what I don't know."

"My personal growth is so important. Now my sixth grade class can work in groups, have discussions and work together The shift from apathy to 'I'm interested in this' is wonderful to see."

• **enhanced coaching sessions with teachers.**

"Now I analyze the teachers I work with form a different view. When I give suggestions, teachers try them. They are now stepping back and allowing kids to work. Everything I do here I use in schools and the teachers love it."

• **helped coaches and teachers to develop a shared belief on what good math instruction should be**

"By having others present to view the lesson (not the teacher) we gain insight about choices we make pedagogically. It's a privilege to get feedback in this way, where it's not about judgment."

"My students have started to develop a habit of thinking beyond procedure and have more of those 'why is that so' questions for me. It is amazing how they are taking it in and understanding. "

• **created a sense of community among a wide range of participants.**

""I learned that working on a lesson as a group is a lot more valuable and insightful than working alone."

"I have always enjoyed working with people. I love when we come back and reflect on our lesson and refine it, and re-do."

"Conversations build relationships and relationships can yield change."

Coaches need a robust and flexible understanding of the mathematics to be taught and a large repertoire of pedagogical content knowledge to make the mathematics accessible to students and engaging to colleagues. Lesson study directly addresses these two components of what coaches need to know and be able to do.

One profound impact of participation in lesson study was, as one coach put it, that in working with teachers, both coaches and teachers were "thinking more comprehensively about the choices they make that best support student learning." Attention is paid to each specific component of a lesson (introduction; context of the task; visuals, handouts; support for particular students; anticipated student responses and misconceptions; questioning; grouping; the share; pacing) during the process and some aspect resonates with each participant/observer.

"It brings to light questions we need to ask ourselves every day — why am I choosing these materials? Why did I pair the students? What do I expect the students to do or say?"

In Region 9, the level of insight and the aspects to which participants could and did attend seemed to correlate to the level of experience in both professional development opportunities and the degree to which they reflected on their practice. For coaches and teachers brand new to the idea of studying teaching, lesson study offered very concrete and relevant insights, ones which can have an immediate and profound impact on classrooms of planning group members and observers. For example, for teachers in one school it was a concern that high expectations had been set by the lesson study group and a revelation that the students were capable of meeting those expectations. For others the seemingly basic tenet that lessons can be easily differentiated to allow entry for all students was an exciting discovery and one they were eager to attempt in their own classrooms.

"It taught me to be more mindful of the different levels of learners in my class."

And, not surprisingly, teachers (including secondary teachers) remarked on learning new mathematics or making connections and gaining insights into math relationships during the process of lesson study.

"What I've realized is that while we [secondary math coaches/teachers] have math content, we are learning different ways to teach math. We are starting to teach investigations. We are experiencing a process."

Coaches particularly found the debriefing protocol helped sharpen their own facilitation and communication skills — make it or break it skills — when working with teachers. One coach who facilitated an elementary school lesson study team shared that it wasn't easy to get teachers with different philosophies to agree on an overarching goal. This process involved demystifying assumptions, the willingness to negotiate and compromise and to examine one's own belief and practice collegially. She indicated that the process had helped her to think about what it would take to build a professional learning community in her school.

A change for the second cycle of lesson study in Region 9 at each level was further involvement of the classroom teachers. Rather than have the coaches meet at a regional site to plan, the groups spread out to the sites at which lesson study would take place. Thus coaches planned not only with the teachers in whose classrooms the lessons would be taught, but also with colleagues at the grade level and any instructional support staff who worked in those classrooms. The impact of this change was far-reaching. Because of the involvement of a core group at the school, coaches saw small cultural changes. Teachers were more willing and eager to plan collaboratively. It was after this second cycle that a few of the schools conducted their own in-house study lesson. The structure of the lesson study process had helped to shape a more collaborative atmosphere in these schools.

Coaches play a key role in creating an environment for risk taking and professional rigor to thrive. And lesson study, with its stress on professional community, paired with content coaching focused on developing mathematical knowledge, a large repertoire of pedagogical content knowledge, and evidence based lesson design, is an excellent vehicle to empower both coaches and teachers, and to develop shared beliefs about teaching and learning.

What foundation is needed for coaches to successfully, systemically improve teaching and learning in schools?

Assuming that our analysis of the present general picture of coaching is fairly accurate, namely, unskilled, inexperienced, coaches (who may be masterful teachers) are being hired by districts in which there is little clarity regarding the role and skill set of the coach, we propose that lesson study for and by coaches is one of a number of long and short term strategies which could be employed to ensure sustainable success. Lesson study encourages the formation of a professional learning community of coaches. This community of coaches is necessary as coaching is even more isolating and idiosyncratic than teaching.

Coaching flourishes in a community in which practitioners are enthusiastically studying the craft of teaching and using evidence of student learning as the main criterion for success. Therefore, when coaches do meet, they need to focus on the work of planning, teaching and assessing (or reflecting), which are the core activities of lesson study. When there is a shared belief that teaching is complex yet learnable and that there is a knowledge base about teaching that might inform the work, coaches become instrumental in propagating research based instructional practices, such as lesson study, and focused, facilitated classroom discourse across a school or district.

We found that lesson study formats *combined* with coaching experiences produced more rigorous lessons and greater professional growth since the growth gained during the study lesson, by *both* teachers and coaches, is sustained and deepened through ongoing coaching. Lesson study, combined with instructional coaching, is a way to organically de-privatize teaching and create a professional community that monitors itself as it upgrades the practice of teaching. Moving from the privatization of teaching to making teaching a public practice is one of the major strategies used to develop professional learning communities within and across schools, which in turn is what coaches need to be cultivating — professional learning communities focused on the core instructional practices of planning, enacting and assessing lessons. Teachers and coaches report over and over again that collaborative planning coupled with watching others teach and then reflecting on the lesson is by far the most helpful professional learning experience for them. Lesson study, with its protocols and emphasis on collaborative lesson design and evidence-based learning, offers a relatively safe and structured way

in which to move toward public teaching. Lesson study, combined with coaching, thus provides a means for building instructional and curricular coherence, often lacking, across a school or district.

Coaching has the potential to upgrade the teaching profession in unprecedented ways because it is a model of professional learning that is centered around the core of instructional practice, site based, ongoing, and by its very nature builds professional learning communities. Coaching is in its infancy and it is proliferating rapidly. We have a wonderful opportunity to shape the role of the coach into one that profoundly impacts the nature of the teaching profession, as we presently know it. Coaches can be catalysts for teaching to take its place among the most honored professions as a result of an upgrade in the professional behaviors and skill level of its practitioners. When done well, instructional coaching not only leaves no child behind, it empowers adults and students alike to reach new heights. It is crucial that the support we hope to give to students and teachers through coaching is also provided to the coaches. Lesson study conducted by a community of coaches is one way to provide support.

References

Ball, Deborah Loewenberg and Bass, Hyman. (2000). Interweaving Content and Pedagogy in Teaching and Learning to Teach: Knowing and Using Mathematics. *Multiple Perspectives on the Teaching and Learning of Mathematics*

Dufour, R.,& Eaker R. (1998). Professional Learning Communities at Work: Best Practices for Enhancing Student Achievement. Bloomington: National Educational Service.

Elmore, Richard F. School Reform from the Inside Out: Policy, Practice and Performance. Harvard Education Press (2004).

Hiebert, J., & Stigler, J. W. (2000). A proposal for improving classroom teaching: Lessons from the TIMSS video study. *Elementary School Journal*

Hill , Heather C., Rowan, Brian and Ball, Deborah Loewenberg. (in press, March 2005). Effects of Teachers' Mathematical Knowledge for Teaching on Student Achievement

Lewis, C., Perry, R., & Hurd, J. (2004). A deeper look at lesson study. *Educational Leadership*

Sonal Chokshi, Barbrina Ertle, Clea Fernandez, & Makoto Yoshida. (2001) Lesson Study Research Group (lsrg@columbia.edu)

West, Lucy & Frances R. Curcio, (2004) Collaboration Sites: Teacher-Centered Professional Development in Mathematics. *Teaching Children Mathematics.*

West, Lucy. (2006). *Coaching As Leadership*, NCSM Monographs

West, Lucy and Staub, Fritz C. (2003). *Content Focused Coaching: Transforming Mathematics Lesson.* Heinemann, NH

Developing Capacity Within A School District To Bring About Change Through Professional Development

Teruni Lamberg, Ph.D
College of Education, University of Nevada, Reno

ABSTRACT:

Teacher professional development is important for supporting teachers to change their teaching practices. However, the effectiveness of the professional development depends upon teachers actually making changes in how they teach. Teachers need support within their school settings to create these changes. Therefore, cultivating capacity within the institutional setting of the school district is an important component of professional development. This article examines how boundary encounters between district leaders, teachers and professional developers/researchers can develop capacity for change within an institutional setting. The role of district leaders as brokers within a professional teaching community and the district leadership community is highlighted. This analysis contributes to the discussion on how institutionally established boundaries of communication can be broken to increase the speed, flexibility, and integration of new and innovative ideas. This paper documents how district leaders, researchers/professional developers and teachers working together can generate knowledge and resources to create an environment for changing math instruction within the institutional context of the school district.

How teachers teach mathematics is influenced by the institutional context of the school district in which they teach. For example, a teacher is expected to teach from the district-chosen curriculum, cover particular content that is in the district standards, and even teach in a manner that is acceptable to administrators. Therefore, when supporting teachers through professional development to change their instructional practices to support student learning, we must understand and work within the institutional context in which teachers teach to create an environment for change to occur.

In this article, I explore the nature of boundary encounters between district leaders, teachers and professional developers/ researchers within a professional teaching community. A boundary encounter occurs when members from different communities engage in activities together. The purpose in doing so is to understand how we can design professional development that can create capacity for change. Therefore, an analytic framework for designing professional development is presented in this paper.

This paper will be organized as follows: First, I will briefly describe current reform efforts in mathematics education as envisioned by the National Council of Teachers of Mathematics (1989) and how professional teaching communities have been conceptualized in the research literature. The purpose in discussing professional teaching communities is because research (Franke, & Kazemi (in press); Grossman, Wineburg and Woolworth 2000; Lehrer and Schauble, 1998;Warren and Roseberry, 1995) suggests that it is an effective means of supporting teacher learning and generative teaching practices. A professional teaching community can be viewed as a community of practice. Therefore, I will elaborate upon the characteristics that make up a community of practice.

Next, I will examine how we could view a school district as being made up of "constellations of interconnected practices." Several communities of practice within a school district influence how teachers teach. Therefore, teaching

becomes a distributed activity (Cobb, McClain, de Silva Lamberg & Dean, 2003).

Understanding how different communities of practice function together through boundary encounters will help us understand how to develop capacity for change within the institutional context of the school district. An individual who interacts in more than one community can be considered a broker. Therefore, I will explore how brokers can impact innovation and change and enhance the boundary encounters that take place between communities.

The ability of new and innovative ideas to be developed and implemented in classrooms determines the success of the professional development efforts. I will elaborate how the quality of communication and the ability of an organization to leverage human and material resources is important for creating capacity for change as suggested in business literature. I will then present data and an analysis from a professional development/research project with middle school mathematics teachers on the nature of boundary encounters and the role of brokers.

Developing Capacity Within the Institutional Context of the School District to Create Change

PROFESSIONAL TEACHING COMMUNITIES AND REFORMED MATHEMATICS TEACHING

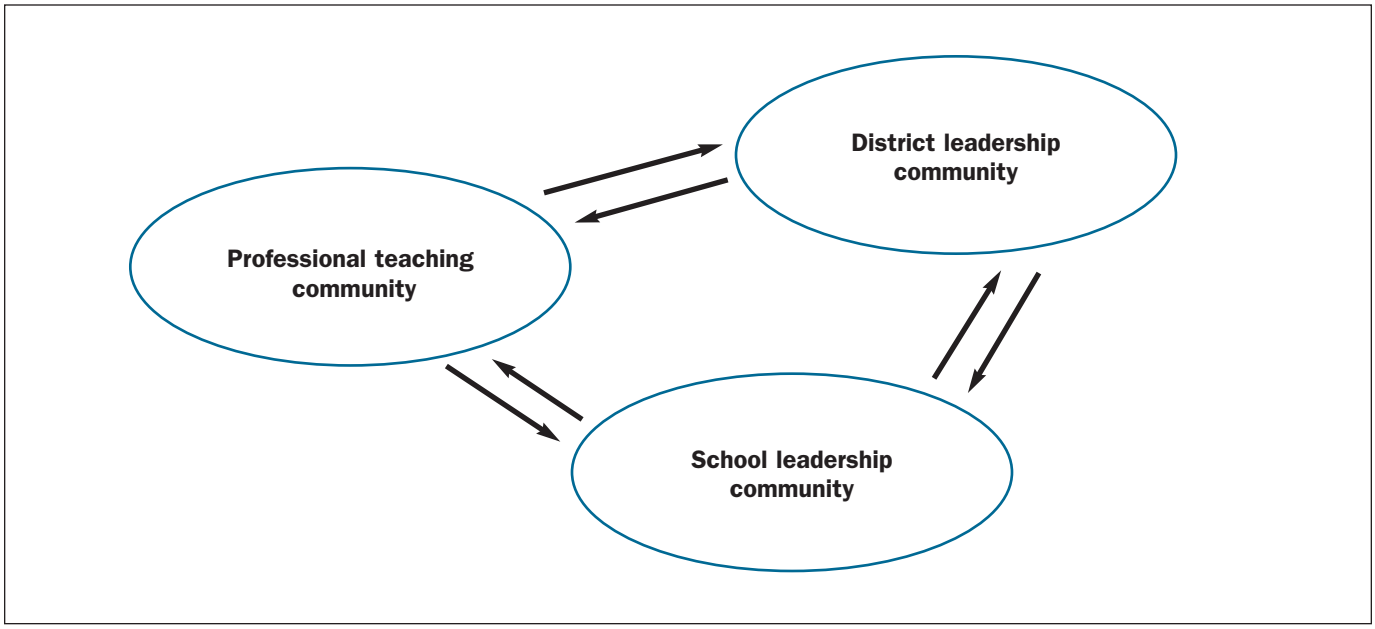
Recent reform efforts in mathematics education have focused on building conceptions of mathematics as a dynamic, socially constructed and inquiry-driven field (National Council teachers of mathematics,1989). Therefore, teaching that is consistent with the mathematics reform as envisioned by the National Council Teachers of Mathematics involves teachers developing generative teaching practices (Franke, Carpenter, Fennema, Ansell, & Behrend, 1998). Generative teaching practices involve teachers making pedagogical decisions based on student reasoning (Franke & Kazemi, in Press). Teaching for conceptual understanding is a complex activity because it involves figuring out how students are reasoning and making pedagogical decisions to support student learning by building on what students know and can do. A professional teaching community can become an arena for teachers to figure out how to support student learning by using each other resources A professional teaching community is a community of practice (Wenger, 1998) situated within the institutional setting of the school district. Typically, in the research literature, professional teaching communities have been conceptualized as a group of teachers working together with a group of researchers. (Franke, & Kazemi (in press); Grossman, Wineburg and Woolworth 2000; Lehrer and Schauble, 1998;Warren and Roseberry, 1995). Understanding how a professional teaching community is situated within the institutional context is important for understanding how boundary encounters with other communities impacts teaching.

SCHOOL DISTRICTS AS CONSTELLATIONS OF INTERCONNECTED COMMUNITIES OF PRACTICES

The institutional context of the school district can be conceptualized as being made up of several communities of practice designed to support instruction. For example, a school district typically has a centralized office, administrators and principals. These communities such as the central office (district leaders), building administrators (principals and assistant principals) and teachers have specific functions in supporting teaching and student learning. Each community can be viewed as a community of practice. According to Wenger (1988), an organization can be conceptualized as consisting of constellations of interconnected practices.

Cobb, McClain, Lamberg & Dean (2003) provide an analytic framework for understanding how teachers' instructional practices are influenced within the institutional context of the school district. The analytic framework is grounded in professional-development work with a group of middle school teachers. We discuss how mathematics instruction can be viewed as a distributed activity particularly influenced by district leadership community, school leadership community and math specialists. This is particularly the case with regard to how teachers organize for math instruction, and how math instruction is made visible. Furthermore, we describe how people in different communities interact with each other through brokers, boundary encounters and boundary objects. We discuss the role of brokers, how boundary encounters take place and how boundary objects are used to describe the interconnections that take place within various communities of practice. Figure 1 on page 47 illustrates how a professional teaching community, district leadership community and school leadership community function independently and together to influence teaching.

FIGURE 1. *School districts as constellations of interconnected practices*



COMMUNITIES OF PRACTICE

People who are part of a community of practice participate in activities through mutual engagement, negotiate meaning through a joint enterprise and possess a shared repertoire of tools (Wenger, 1998). This means that people within a community of practice have developed ways of interacting with each other and thinking that might be unique to that particular community of practice and unfamiliar to outsiders. Participants form close relationships and develop idiosyncratic ways of engaging with one another, which outsiders cannot easily enter. In particular:

1) They have a detailed and complex understanding of their enterprise as they define it, which outsiders may not share.

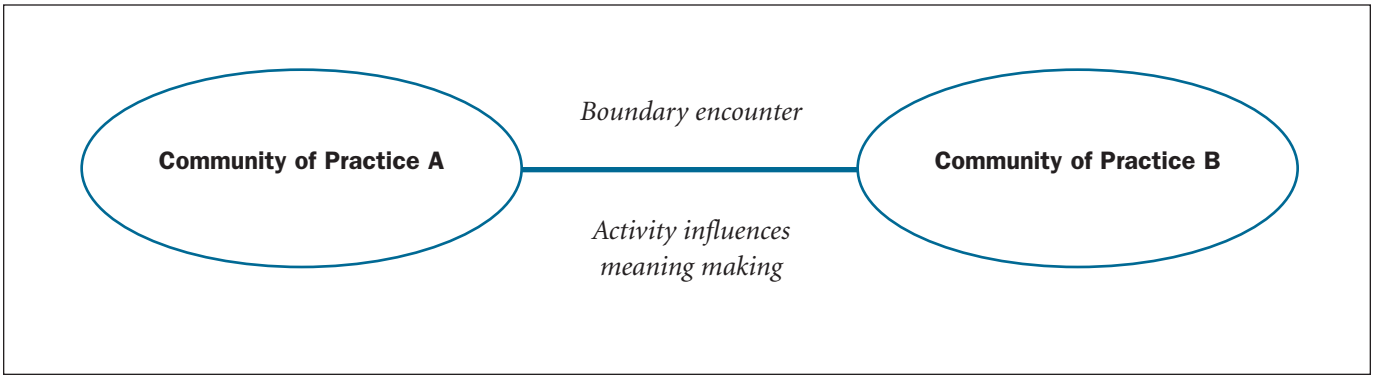
2) They have developed a repertoire for which outsiders miss shared references. (Wenger, p.113).

The nature of interactions between the communities through boundary encounters impacts the level and type of interconnections and relationships that exist between communities. The section below will elaborate upon boundary encounters.

BOUNDARY ENCOUNTERS

When brokers from different communities of practice interact through participation or reification, then a boundary encounter takes place (Wenger, 1998). A broker is a member from one community of practice who makes connections with another community of practice (Wenger, 1998).

FIGURE 2. *Boundary encounters between two communities of practice.*



A boundary encounter *(see fig. 2)* can take many forms such as meetings, conversations and visits (Wenger, 1998). The type of interaction that takes place during boundary encounters influences the meaning that is made between brokers. Ultimately, how respective communities align perspectives and meaning is influenced by the nature of the boundary encounter. For example, Cobb et al. (2003) provides examples of brokers within a school district engaging in boundary encounters, such as a principal conducting a drop-in visit to observe a teacher. This type of interaction involves an encounter between the teaching community and the leadership community. Boundary encounters can occur within a professional teaching community as teachers and brokers from other communities engage in professional development activities together.

An Organization's Capacity To Bring About Change Through Innovation

In this section, I examine business literature on how organizations develop capacity to bring about change. There are two themes that emerge from the business literature in relation to boundary encounters. These themes revolved around the nature of information or knowledge that gets shared or co-created, and also the ability of an organization to leverage material and human resources. The quality of these boundary encounters influences an organization's capacity to bring about change of innovative ideas. The same holds true in a school district setting.

According to Rogers (1995), organizations need to speed up the rate of diffusion of innovation within a social system so that change can take place. Communication that takes place within the social system of the organization and the sharing of ideas so that mutual understandings are developed influences the success of the innovation being adapted.

The nature of interactions between different communities and brokers can determine the quality of meaning that is made and mutual knowledge that is shared. The interactions through boundary encounters can remain at a very surface level or reach a deeper mutual understanding of each other's perspective. For example, when brokers from different communities of practice interact within an organization, they may interact with each other in their institutional hierarchical roles. A district leader may interact with teachers to provide professional development from a district leader's perspective of implementing wide scale reform, whereas, a teacher may interact with the district leader from a teacher's perspective. The understandings and goals of each community are different. Unless deeper communication takes place, the boundary encounters may remain at a surface level. A surface level exchange of information may take place, such as sharing of facts, instructions, procedures and artifacts.

From a business perspective, Ashkenas, Ulrich, Jick and Kerr (2002) discuss how organizational boundaries can be broken to increase speed, flexibility, integration and innovation needed to survive and thrive in today's business world. These ideas can be applied to working within the institutional context of the school district as well. They point out that, when people interact in their designed formal roles, the nature of their interaction may be rigid. This can cause a breakdown in communication and prevent new ideas from being generated. Therefore, when brokers interact, how they relate to each other and communicate issues and problems can lead to shared meanings. Speed refers to being responsive to customers in a market. Flexibility involves the ability of an organization to allow people to do multiple jobs and learn new skills. According to Ashkenas et al, role clarity constrains flexibility, especially when people are locked into specific roles and responsibilities and become unwilling to jump in a moment's notice.

Organizational resources need to be leveraged to bring about change as well. When brokers develop shared meaning and knowledge, they can leverage the organizational resources to make change happen. Gamaron et. al. (2003) point out those organizational resources can both enable and constrain activities of a group. They particularly referred to material, human and social resources. Therefore, when conducting professional development to bring about change in teachers' instructional practices, we need to leverage the organizational resources to bring about the change. This can only happen when brokers within the organizational resources develop shared meaning. Failure of innovation to be integrated through professional development may be attributed to failure of communication between brokers who are charged with system-wide change. On the other end of the spectrum, the interaction between brokers can develop negotiated meaning where ideas are shared and new ideas and meanings are negotiated. In this situation, brokers develop a shared meaning between the communities of practice.

The following section of a paper presents data from a professional development project that we conducted with middle school teachers. Our goal was to facilitate the

development of professional teaching communities.[1] Initially, teachers and researchers interacted together in professional development sessions. At a later date, we invited the district leaders to become part of the professional teaching community. This paper does not elaborate upon how we became a professional teaching community or the process by which the district leaders became part of the professional teaching community. Rather, I will focus on the nature of boundary encounters that took place between the professional teaching community made up of researchers, teachers and district leaders. I will focus on how the boundary encounters facilitated communication and leveraged organizational resources to develop capacity for change.

Methodology

The data presented in this analysis is from collaborations with a group of middle school teachers in a southern state for the past four years. A research team from Vanderbilt University had been meeting with the teachers once a month for six times during the school year and also during the summer for a workshop. We facilitated professional development sessions to help teachers develop generative teaching practices for mathematics instruction. Initially, the professional development sessions involved interactions between researchers and teachers. We wanted teachers to feel comfortable interacting with us. However at a later date, we decided to invite the district leaders to participate in the professional development sessions. The district leaders became part of the professional teaching community through their participation in the professional development sessions. It should be noted that it took 18 months before we could consider the professional teaching community as having a joint enterprise. Until that time, the interactions that took place during the work sessions fit what Grossman, Weinburg and Woolworth (2000) called pseudo-agreements that serve to mask differences in view points.

The school district where the study took place is an urban district that serves 60% minority student population. It is located in a state with a high stakes accountability program. The school district had received external funding to support reform of mathematics instruction. The district leadership community comprises a mathematics coordinator and 4 math specialists who serve 8 middle schools. The district leaders coordinate math reform in the district. The math specialists coordinate the professional development in the district and they also provide classroom assistance.

The data collected within the larger context of the study included videos of the professional development sessions during the school year and also the summer sessions from 2001-2003. The data also include interviews of the district leaders conducted by the research team.[2] The district math leaders interviewed include the math coordinator and the math specialist who worked with the schools represented in the professional teaching community. Detailed fieldnotes from each professional development session and interviews were recorded. The snowballing methodology (Spillane, 2000) and the constant comparative method of Straus and Corbin (1998) were used to collect and analyze the data.

The snowballing methodology used within the larger context of the project included semi-structured audio taped interviews with the teachers to identify how their math instruction was impacted within the institutional context of the school district. The issues addressed in these interviews included professional development activities in which the teachers participated, their understanding of district policies for math instruction and the lines of accountability, and their informal networks and official sources of professional assistance. Then we administered a survey to identify individuals who influence math instruction and conducted a second round of interviews to identify agendas relating to math instruction.

The Strauss and Corbin (1998) constant comparative method was used in the following manner. All professional development activities and formal and informal interactions with teachers, researchers and district leaders were chronologically documented. A matrix was created to record themes and key events that emerged from the data. Particularly, we were interested in the meaning that was made in relation to activities that took place in the professional development sessions and informal meetings within the institutional context of the school district. Emerging

[1] The research/ professional team consisted of Paul Cobb, Kay McClain, Teruni Lamberg, Chrystal Dean, Lori Tyler Qing Zhao and Jana Viskonovska at Vanderbilt University.

[2] Paul Cobb & Teruni Lamberg

themes that were categorized included the activities that took place during the professional development session, and teacher learning (mathematical and pedagogical), nature of relationship within the institutional context (teachers or district leaders), and reported affordances and constraints for teaching within the institutional context. I was able to examine the data chronologically and also across the matrix to examine boundary encounters that took place. The analysis of the data revealed the results discussed in the next section.

Results

As district leaders became part of the professional teaching community, informal relationships developed, shared meaning was constructed through participation and reification, and human and material resources were made accessible to bring about change within the institutional setting of the school.

• Informal relationships influenced the nature of communication

The informal relationships and friendships that developed between researchers, district leaders and teachers as the professional teaching community formed, influenced the type of communication that took place between different people. The initial communication that took place involved exchange of information. For example, the researchers were interested in understanding how the district was organized. Therefore, we asked the district leaders questions about the design of the institutional context and their formal roles as district leaders. We asked questions such as the district leaders' vision for mathematics instruction? What was the district curriculum and resources used? The district leaders shared information with the researchers during informal meetings. The initial exchange of information between the district leaders and teachers in the professional development sessions involved providing information about district-reformed curriculum, testing expectations and providing logistical support such as providing a space to meet.

As the professional teaching community began to form, the district leaders, teachers and researchers met informally for dinner and friendships began to develop. This changed how people communicated and interacted with each other informally as well as how they participated in the professional development sessions. An atmosphere of trust and openness in communication began to develop. For example, the district leaders shared with the researchers the challenges they faced when attempting to implement reformed curriculum within the district. The teachers openly shared constraints within the institutional context to support shifts in their teaching practices towards focusing on student understanding. They talked about the lack of joint planning time and the lack of instructional leadership from their school leaders. The researchers shared their analysis of the institutional context. The communication that took place was not constrained by the brokers' institutional roles for sharing information from a hierarchical structure of the designed organization of the school district. The comfort level contributed to the de-privatization of teaching and sharing of meaning across boundaries of the different communities of practice that was part of the professional teaching community. This was different than at the initial stages of the project. During that time, the teachers did not disagree with each other and they were concerned about how their comments would be construed by other members who attended the professional development sessions.

• Sharing of knowledge and information from multiple perspectives

As teachers, researchers and district leaders interacted during the work sessions; information and knowledge from respective communities of practice were shared. Therefore, issues and perspectives that were unique to the district leadership, teachers and researchers were shared within the professional teaching community that related to the joint enterprise of the professional teaching community. Getting the support of school leaders to become instructional leaders so that they could have joint planning time and support to teach for student understanding became part of the joint enterprise of the professional teaching community. For example, a discussion took place during the professional development session on how teachers could jointly plan lessons together so that they could problem solve and collaborate. The teachers expressed that there were too many demands on their planning time, and also that they worked in isolation with little opportunity to collaborate with each other. The district leaders listened to the teachers and expressed that planning time was a district wide issue. This is an example of teachers expressing constraints within their teaching community and district leaders communicating the district leadership point of view with regard to planning time. This gave the teachers insight that their isolation in teaching practices is not unique to a classroom or school, rather it is a district-wide issue.

Furthermore, the role of testing and its influences of teaching practices became explicit. These types of interactions also gave brokers the opportunity to find commonalities between the communities and also to develop a deeper understanding of the issues from different perspectives. The following conversation illustrates how ideas from various perspectives were shared and a joint understanding emerged within the professional teaching community.

Researcher: They (the teachers) have planning time but other stuff gets put in. In other words, it is not a high priority.

Teacher 1: Teacher workdays are mandates. This time gets used up with parent conferences…

Researcher: Why aren't the principals giving priority to instructional issues when it comes to it?

Teacher 1: Sometimes they turn information (on test scores) to us as they get it. My principal has made it clear that math scores and reading scores have to be raised.

Researcher: There seems to be differences between the schools. What do many of them (school leaders) think that teaching is about? It is not a problematic. . . The principals focus on class objectives and management issues and think that everything would work out. That was our conjecture. The principals view math instruction as pretty routine and it does not involve specialist knowledge.

Teacher 1: The principals think that if you give kids notes and have them learn it, the kids would be able to do the math. They don't focus on if kids really understand the concepts. The questions for the (standardized testing) require multi steps. Therefore, the teachers are expected to provide support.

District Leader: I think I disagree that it avoids understanding. There is a lot of understanding in the (standardized test). I think the test would reward thinking.

Teacher 3: The test should be shorter. They are not testing for understanding because they have so many questions. Rather kids are tested on their test taking skills.

Teacher 2: Are principals thinking of math teaching as routine activity?

Researcher: This fits with how many district administrators view math instruction. If you view math as continually trying to get a handle on kids thinking and adjusting, then math teaching is a pretty complex activity and there is a need for collaboration. If you form teaching with kids thinking in the center it is a different orbit. …However, the principals talk about math instruction in generic terms as real world issues, group work. However, their goal for math instruction with a focus on understanding has not changed. The teachers' goal is (student) understanding.

This conversation is an example of brokers from multiple communities sharing information within their professional teaching community related to the joint enterprise of the professional teaching community and their respective communities. In other words, multiple voices and perspectives of practices from the teachers, researchers and district leaders were shared. This type of sharing of ideas and perspectives helped the members of the professional teaching community to develop a shared understanding and understanding of multiple perspectives.

• ***Generation of innovative ideas that are jointly constituted***
New and innovative ideas for creating conditions for changing teaching practices within the school district were jointly constituted among the teachers, researchers and district leaders. For example, the agenda of the professional teaching community shifted to getting the principals involved as instructional leaders. The teachers wanted the principals to provide them with resources such as joint planning time so that they could collaborate and plan together to support student learning. The researchers, district leaders and teachers jointly constituted the process that they took to approach the principals. The researcher explained to the district leader that the teachers within the professional teaching community had interviewed 8th-grade students on some fraction tasks. It turned out that the 8th-grade students did not have a conceptual understanding of what "1/3" represented as a quantity. A discussion ensued, regarding the dilemma that if you follow the principals' directive, then you cannot adjust to students' reasoning, and so teaching procedures becomes ineffective. The following excerpts of the discussion that took place illustrate how ideas were generated to get the principals support to focus on students' conceptual understanding.

Researcher 1: If we agree that the different views that match teaching, and if you think it is important to

change their (school leaders') view and they see it valuable and it is in their interests. . . They (the school leaders) don't see any relation between that or (Standardized test) scores and what you are suggesting and we are thinking about the evidence.

District Leader: Using the vocabulary of (newly adopted program) would be a useful way to communicate to the principals etc.

Researcher 1: We have to speak their language that they understand in generic terms. The Superintendent really values the (new adopted program) design qualities. *(The researcher explains that he wants the understanding and memorization to work together because there is a strong correlation between the quality of thinking and how students are taught).*

Teacher 1: We should give the evaluating powers that be, (the) obvious examples of the (design qualities) of what we are working on such as linear models.

(Researcher 1 cautioned the teachers by saying the principals are going to understand these words from the perspective of their current understanding — i.e., a demathematized view of reform; the same traditional goals but different strategies.

Researcher 1: You have to prepare the ground so that they could have authentic problems.

Researcher 2: Just telling them to teach differently is not going to work.

Teacher: Just going through reformed curriculum is not enough. She needs to be able to explain to the principals why she needs to go to study groups.

Researcher 1: How you teach kids for understanding — you work on problems and situations hard to work on the reasoning? We have to put kids reasoning at the center.

Researcher 2: If you view mathematics as a routine activity, one way to approach the principals is to show that this way is not working.

(Researchers pointed out that the principals do not have to get to the same level of expertise as the teachers. But they need to get to some point so that they would be able to provide support. They added that these findings are consistent with the policy materials they have been reading.)

District leader: I think in middle school it is more a generalized view of instruction and if you keep order in the room and the kids are reasonably happy and the principals are in various places of with regard to integrated math. My goal is to have students learn meaningful mathematics for all students. Gifted kids have access to certain materials. *(District leader informed the teachers that there was going to be an administrators meeting with the school leaders and they might be able to communicate with them at that time.)*

The following ideas were displayed on a chart paper created by the teachers.

Where are the principals now?
- Teaching is a routine, sequential, predictable,
- Focus is on management and covering content.
- Demathematized view

Where do we want principals to be?
- Appreciate teachers' expertise knowledge
- Knowledge of kids reasoning
- Importance of understanding kids mathematical thinking
- Importance of collaboration to support, focus on student reasoning.

Researcher: One of the things you were talking about you working through a lot of the problems, what are you getting out of that the math point of view.

Teacher: figuring out what to do with kids' misconceptions was valuable.

Teacher 2: It is hard to have a conversation with yourself in isolation. When you are collaborating you get the initial goals of mathematics. You get to see what your kids are doing.

District leader: One of the things that we are doing with another researcher is a student interview. The teachers would get to view a student who scored high on the (standardized testing).

At this point, the teachers decided to try some tasks with students through interviews so that principals would get to observe student thinking.

The teachers, researchers and the district leaders jointly constituted the joint enterprise of the professional teaching community by sharing and negotiating multiple perspectives. The researchers provided insight on research on student thinking and policy, the teacher provided insight on how the principals view instruction and how they are held accountable, and the district leaders provided insights on how to communicate with the principals so that they could understand the goals of the professional teaching community. The professional teaching community reached a decision to get principals' attention to focus on student reasoning by having them observe students solving fraction tasks. They did this through a process that involved figuring out how to effectively communicate, how to implement the plan, and what the end goals would look like.

• ***Generation of material and human resources within the institutional setting to bring about change.***
Human and material resources became available and accessible as brokers from multiple communities participated within the professional teaching community. Therefore, the professional teaching community was able to take action to bring about changes within the institutional setting to influence math instruction. These resources were made available to further the joint agenda of the professional teaching community.

For example, the district leaders provided funding to send principals to visit another school district, which had school leaders who were instructional leaders. They did this because the joint enterprise of the professional teaching community involved supporting principals to become instructional leaders. This is an example of how material resources can be generated within the institutional context of the school district to further the agenda of the professional teaching community. In addition, the district leaders viewed it as a means to enhance their own knowledge to further their joint enterprise of providing professional development. The district leaders were particularly interested in understanding how the other school district incorporated teacher leaders to support math instruction.

The researchers were able to make arrangements for the teachers, school leader and a district leader to visit another school district. This is an example of how human resources are needed to generate change through the contribution of the researchers to coordinate meetings. In addition, the district leaders invited teachers to participate in district-wide decisions that involved mathematics instruction. As a result, the teachers began to have a voice within the district. This is an example of how district leaders and teachers within the professional teaching community had developed a shared understanding and became a resource for each respective community of practice.

Discussion

A community of practice that works together to bring about change is a community of action (Axelrod, 2000). However, a professional teaching community does not exist in isolation, rather it is situated within a "constellation of interconnected practices" within a school district. The effectiveness of a professional teaching community is dependent upon teachers being able to gain access to material and human resources to support change in their teaching practices. Therefore, we need to

- create capacity within the school district to support teachers implement innovative ideas and refine their teaching practices;

- reconceptualize a professional teaching community to include more brokers from other communities besides teachers and researchers/ professional developers, as described in the research literature (Franke, & Kazemi (in press); Grossman, Wineburg and Woolworth 2000; Lehrer and Schauble, 1998;Warren and Roseberry, 1995).

Furthermore:

- Researchers/professional developers must include math coordinators, math specialists; professional development coordinators as active parts of a professional teaching community. This is in contrast to interacting with them as peripheral participants.

Boundary encounters that take place between communities, such as the professional teaching community, district leadership community and school leadership community are the critical links that connect these communities together. The level of communication that takes place is critical for innovative ideas to be implemented and resources within the institutional context to be leveraged to create change. Different communities have access to different resources. For example, the district leadership community has access to material and human resources that teachers do not have direct access to. Furthermore, the sustainability of a professional teaching community is dependent upon material and human resources as well Gameron (2003).

The quality of relationships, trust and communication that take place through boundary encounters impacts an institutional capacity for innovation and change. The quality of boundary encounters between brokers is critical for an organization such as a school district to be able to integrate new and innovative ideas, as suggested in the business literature(Ashkenas, Ulrich, Jick and Kerr, 2002). As Wenger (1998) points out, people in a community of practice have unique ways of interacting and communicating with each other. This makes it more difficult for brokers to communicate without becoming part of another community of practice.

The boundary encounters that develop into mutual understanding and integration of multiple perspectives lead to more effective communication and action. The relationships that developed in the study aided the breakdown of organizational barriers of communication and the ability for members from different communities to openly discuss ideas and to communicate information back and forth. This afforded knowledge and information to travel quickly within the institutional setting. Therefore, there was a shift from teachers, researchers and district leaders working in isolation in discrete communities to working within networks of practice.

References

Ashkenas, R., Ulrich, D., Jick, T., & Kerr, S. (2002). *The boundaryless organizational structure.* San Francisco, CA: Jossey-Bass.

Axelrod, R. (2000). *Terms of engagement: Changing the way we change organizations.* San Francisco, CA: Berrett-Koehler Publishers, Inc.

Cobb, P., McCLain, K., de Silva Lamberg, T., & Dean, C. (2003). Situating Teachers' Instructional Practices in the Institutional Setting of the School and District. *Educational Researcher,* 32 (6), 13-24.

Dixon, N. (2000). Common Knowledge: How companies thrive by sharing what they know. Boston, MA, Harvard Business School Press.

Franke, M. L., & Kazami, E. (in Press).Teaching as learning within a community of practice: Characterizing generative growth. In T. Wood, B. Nelson, & J. Warfield (Eds.), *Beyond classical pedagogy in elementary mathematics: The nature of facilitative teaching.* Mahwah, NJ: Erlbaum.

Franke, M. L., & Carpenter, T., Fennema, E., Ansell, E. & Behrend, J. (1998). *Understanding teachers' self-sustaining, generative change in the context of professional development.* Teaching and Teacher Education, V. 14, No. 1, pp, 67-80.

Gamoran, A., Anderson, C. W., Quiroz, P.A., Secada, W.G., Williams, T., & Ashman, S. (2003). Capacity for change: *How districts and Schools support teaching for understanding in mathematics and science.* New York: Teachers College Press.

Grossman, Wineburg, Woolworth (2000). *In pursuit of Teacher Community.* Paper presented in the American Educational Research Association. New Orleans, LA.

Lehrer, R., & Schauble, L.(1998).*Developing a community f practice for reform of mathematics and science.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Rogers, E. (1995). *Diffusion of innovations.* (Fourth Edition), New York: Free Press.

Spillane, J. (2000). Cognition and policy implementation: District policy makers and the reform of mathematics education. *Cognition and Instruction,* 18, 141-179.

Strauss, A. L., & Corbin, J. (1998). Basics of qualitative research: *Techniques and procedures for developing grounded theory.* London: Sage Publications

Talbert,J.E., & McLaughlin, M, W. (1999). Assessing the school environment: Embedded context and bottom-up-research strategies. In S. L. Friedman & T.D. Wachs (Eds.), *Measuring environment across the lifespan* (197-226). Washington, D.C. American Psychological Association.

Thorn, C.A. (2001, November 19). Knowledge Management for Educational Information Systems: What Is the State of the Field?, *Education Policy Analysis Archives*, 9(47). Retrieved [date] from http://epaa.asu.edu/epaa/v9n47/.

Warren, B & Rosebery, A. S. (1995). Equity in the future tense: Redefining relations among teachers, students, science in linguistic minority classrooms. In W. Secada, E. Fennema, & L. Byrd (Eds.), *New directions in equity for mathematics education* (pp.298-328). New York: Cambridge University Press.

Wenger, E., McDermott, R., & Snyder, W. (2002). *A guide to managing knowledge: Cultivating communities of practice.* Boston, MA: Harvard Business School Press.

Wenger, (1998). *Communities of practice.* New York: Cambridge University Press.

A Mathematics Teacher Leader Profile:
Attributes and Actions to Improve Mathematics Teaching & Learning

Jan Yow
University of North Carolina at Chapel Hill

In response to *A Nation at Risk* (1983), two different groups looked at high quality teaching: the Carnegie Task Force on Teaching as a Profession and the National Council of Teachers of Mathematics (NCTM). Discussions of high quality teaching naturally leads to a growing emphasis on teacher leadership, high quality teachers who guide others (Dozier, 2004). Having effective mathematics teacher leaders is crucial to improve mathematics teaching and learning. In this article, I begin by presenting the national document created by these two groups and the profiles they offer for teacher leaders. Next, I review the literature on teacher leadership in general and mathematics teacher leadership, more specifically. Then, based on the national documents, research, and my experience working with teachers who want to become teacher leaders, I propose a mathematics teacher leader profile, including attributes and actions. Following the profile, I address measures that teacher leaders can take to help both themselves and colleagues create a mathematics reform classroom environment. I close with concluding remarks and what I envision as the future of mathematics teacher leaders.

National Teacher Leader Profiles

As stated earlier, both the Carnegie Task Force and NCTM responded to the 1983 report with documents emphasizing how schools and teachers could be better prepared for national school improvement. These offered recommendations and included national standards to ensure that all children were receiving a high quality education (NCTM, 2000). One of the main recommendations by the Carnegie Task Force was to create a national certification for teachers founded on high standards and addressing the prompt *What teachers should know and be able to do*. NCTM's *Professional Standards for Teaching Mathematics* (1991) addressed what high quality teaching looks like in mathematics education. These two documents offer some beginnings in looking at attributes of a mathematics teacher leader.

Carnegie Task Force: National Board for Professional Teaching Standards

The Carnegie Task Force report argued that "teachers should become leaders in curriculum, instruction, social redesign, and professional development and that the real power to improve achievement lay with teachers" (Lieberman & Miller, 2004). Upon the recommendation of the Carnegie Task Force, the National Board for Professional Teaching Standards (NBPTS) was created as a national certification process for classroom teachers. The Carnegie Task Force and ultimately the NBPTS knew high quality teaching existed and needed to be nationally recognized and documented. The NBPTS offers five propositions followed by more specific detail to answer the central focus of *What teachers should know and be able to do*.

These five propositions provide a possible profile for teacher leaders (See Appendix A for the complete list). Proposition 1 states *Teachers are committed to students and their learning*. Teachers recognize that all students are unique, understand how students learn, treat students equitably, and change their practice accordingly. Proposition 2 says *Teachers know the subjects they teach and how to teach those subjects to students.* Teachers know the complexities of their subject, how to present those complexities to students, and provide multiple paths to student understanding. Proposition 3 states *Teachers are responsible for managing and monitoring student learning*. Teachers invoke

multiple methods of teaching, promote collaborative learning, and consistently check student progress. Proposition 4 says *Teachers think systematically about their practice and learn from experience*. Teachers make difficult choices and call on colleagues and research to inform their practice. Proposition 5 states *Teachers are members of learning communities*. Teachers collaborate with other professionals, parents, and the community (NBPTS, 2005).

NCTM: Professional Standards for Teaching Mathematics

In 1991, NCTM's publication of the *Professional Standards for Teaching Mathematics* was an attempt, like the NBPTS, to set a national precedent for what "good" mathematics teaching looked like to help students, teachers, parents, administrators, teacher educators, and policy makers "see" high quality teaching. With the publication of these standards, the discussion around high quality mathematics teaching became a little easier; a document now existed from which the conversation could begin.

The document contains four different sets of standards, all addressing quality mathematics teaching (See Appendix B for the complete list). The first set, *Standards for Teaching Mathematics*, includes worthwhile mathematical tasks, both the teacher and student role in discourse, and the analysis of teaching and learning. The second set, *Standards for the Evaluation of the Teaching of Mathematics*, addresses teacher participation in evaluations, mathematical concepts, mathematical dispositions, and mathematical understanding assessment. The third set, *Standards for the Professional Development of Teachers of Mathematics*, includes experiencing good mathematical teaching, knowing mathematics and school mathematics, and developing as mathematics teachers. Finally, the fourth set, *Standards for the Support and Development of Mathematics Teachers and Teaching*, addresses the responsibilities of policy makers, schools, universities, and professional organizations in improving mathematics education (NCTM, 1991).

Teacher Leadership Literature

As the NBPTS and NCTM provide possible profiles for teacher leaders, others have also done research on the topic. In 1991, Pat Wasley was one of the first researchers to use data from teacher interviews and observations in her book *Teachers Who Lead: The Rhetoric of Reform and the Realities of Practice*. In interviewing and observing three teachers leaders, Wasley profiled each to allow others to "see" what teacher leadership looked like. In these three in-depth case studies, Wasley was shocked at the complexity of the teacher leader role (Wasley, 1991). The roles involved power, authority, decision-making relationships, different kinds of collaboration, and communicating beliefs about teaching and learning. Factors that allowed these teacher leaders to be successful with their colleagues also constrained them. In this section, I review more general literature on teacher leadership, like that of Wasley's book, and then I look at more specific mathematics teacher leadership literature.

Teacher Leadership

Related to Wasley's work, other researchers have surveyed, interviewed and observed teachers in order to better understand teacher leadership. Several common themes emerge throughout research findings: trust and relationships, political understanding, knowledge of change, and teaching and learning expertise.

Trust and the importance of building relationships with colleagues, administrators, and community members is a shared characteristic across the research. Teacher leaders employ a set of skills involved in building both trust and rapport in addition to creating a confidence in others (Miles et al., 1988). Management of interpersonal relationships and communication skills are characteristics of teacher leaders (O'Connor & Boles, 1992).

In addition to trust, teacher leaders also are aware of the political climate in which they work. They understand how power and authority contribute to decisions made in education (O'Connor & Boles, 1992). Teacher leaders recognize that schools operate as organizations dealing with power dynamics (Miles et al., 1988). Teacher leaders use their knowledge of the political climate in making decision and building relationships (Lieberman & Miller, 2004). Connected to trust, Fullan (2002) says teacher leaders embody a sense of "moral purpose" which he defines as a "principled behavior connected to something greater than ourselves that relates to human and social development" (Fullan, 2002).

As change is inevitable, teacher leaders understand its impact on schools and the teaching and learning that take place within them. Teacher leaders have a clear knowledge of how change happens (Fullan, 1994). They can also deal with change as well as adapt when it occurs (Miles et al., 1988; O'Connor & Boles, 1992). This adaptability prevails in teacher leader characteristics.

Another characteristic of teacher leaders is their expertise of teaching and learning. Teacher leaders not only understand the complexities of teaching and learning (Fullan, 1994), but also influence their peers in the two endeavors (Katzenmeyer & Moller, 2001). They understand that teaching and learning are lifelong processes. Teacher leaders engage in self-inquiry and share their discoveries with colleagues (Miles et al., 1988; Lieberman & Miller, 2004).

Throughout these various lists of teacher leader characteristics, there is considerable overlap. Many researchers seem to agree on the importance of building trust among colleagues and being a part of a learning community. Also, many mention the importance of understanding how organizations work and the political arena within which schools operate. Several researchers mention the understanding of the change process and the willingness to take risks as key components to teacher leadership.

Mathematics Teacher Leadership

As the literature on teacher leadership has grown over the years (York-Barr and Duke, 2004), some researchers are beginning to concentrate on more specific forms of teacher leadership. In this section, I look at literature that specifically addresses teacher leadership in the context of mathematics education.

Similar to the literature on teacher leadership, this body of literature also finds that teacher leaders build relationships and understand the change process (Miller et al., 2000). More specifically, this body of literature focuses on the teacher leader's expertise in mathematics and the mathematics classroom (Langbort, 2001). In her list of *Who are Teacher Leaders?*, Langbort lists eighteen attributes of a mathematics teacher leader including being a mentor to other mathematics teachers, a spokesperson for mathematics education, and an active member of the mathematics education community.

Being a mathematics teacher leader also involves understanding the complexities of the change process (Fullan, 1994). Research into professional development of mathematics and science teachers has revealed just how complex the change process can be. The Concerns Based Adoption Model (CBAM) outlines the stages teachers go through when implementing an innovation, such as new curricula, that they may or may not support (Hall & Hord, 1987; Loucks-Horsley, 1996). Even change supported by a teacher leader can be difficult; the CBAM model offers insight into the implementation process. The Concerns Based Adoption Model (CBAM) "applies to anyone experiencing change" and holds that "people considering and experiencing change evolve in the kinds of questions they ask and in their use of whatever the change is" such as "What is it? How will it affect me?…Is this change working for students? Is there something that will work even better?" (Loucks-Horsley, 1996). With assumptions such as the importance of understanding the change process from the participant's view, the complexities of mathematics teacher leadership are clear.

Another complexity found in the literature calls teacher leaders to develop relationships and build a "critical mass for change" (Miller et al., 2000). A crucial factor that both Miller et al. (2000) and Fullan (1994) address is the need to build relationships with individuals who hold different opinions or may disagree with one another. Sustainable change does not occur when the critical mass for change all look alike and think alike. Langbort (2001) talks more specifically to the classroom teaching practice of mathematics teacher leaders and also to their responsibility to represent mathematics education to the larger community.

A Mathematics Teacher Leader Profile

Thus far, the literature on teacher leadership has largely offered teacher leader attributes with few including specific examples of how those attributes are enacted. As the mathematics teacher leaders are crucial in improving teaching and learning, a need exists for more concrete examples of how teacher leaders would translate those attributes into action. Therefore, I created a profile of a mathematics teacher leader that includes not only attributes, but also actions.

The profile is organized in a table (Table 1) to make it as clear as possible. The first column simply lists numbers to aid in referring to the attributes in the discussion following the profile. The second column addresses the "Attributes" necessary in teacher leadership. The third column addresses the "Actions" that a teacher leader with that attribute would take to improve teaching and the profession. The fourth column provides references from the literature that support each attribute.

I do not consider this an exhaustive list of all the attributes of a mathematics teacher leader, as I am sure others may alter it. Rather, this list is my attempt to incorporate my own thoughts about teacher leadership with the previous

attributes found in the literature. The inclusion of thirteen attributes was not intentional on my part, I merely made a list of the attributes that best described a mathematics teacher leader and when I finished, thirteen attributes and actions were the result. Whereas some may see the action statements as narrowing, the intention is to offer practical examples of how each attribute may be enacted in practice. I see the actions as mere beginnings from which to build a longer list and hence a stronger connection between a general attribute and a concrete action.

TABLE 1: ***Attributes and Actions of Mathematics Teacher Leaders***

#	Attribute	Action	Literature Support									
			Miles et al. (1988)	NCTM (1991)	O'Connor & Boles (1992)	Fullan (1995)	Miller et al. (2000)	NCTM (2000)	Katzenmeyer & Moller (2001)	Langbort (2001)	Lieberman & Miller (2004)	NBPTS (2005)
1	Mathematical content expert	Teacher continually participates in mathematical content professional development through school, district, and local universities.		X			X					
2	Mathematical pedagogical content expert	Teacher continually participates in mathematical pedagogical content professional development including lesson study groups as well as collaborative observation teams to critically study practice in constructive ways.	X	X			X	X			X	X
3	Cultivates teacher leaders	Teacher builds teacher leaders. Just as teaching has the ultimate goal of making teachers unneeded, so too does leading have the ultimate goal of making leaders unneeded.	X	X		X	X			X	X	X
4	Able to look objectively at own practice and be open to change	Teacher participates in teacher research and lesson study, recognizing that change means "bumpiness" (Fullan, 2005). Fullan (2005) used the example of a rock and simple physics: A rock that is still does not want to move. It only takes a small bump to roll the rock. Once the rock is rolling, it does not want to stop. "Whatever something is doing, it wants to keep doing" — known as inertia.			X	X					X	X
5	Gains trust	Teacher genuinely listens and cares about others' opinions (particularly those in disagreement) of students, colleagues, administration, and the community.				X	X		X	X	X	
6	Member of a learning community (Wegner, 1998)	Much research (Wegner, 1998) has been done recently about professional learning communities. Both Barth (2001) and Fullan (2002) say teacher leadership cannot happen with individuals; it must happen in groups. Teachers intentionally join communities of practice where they discuss classroom teaching and new strategies. Members of the group must have varying viewpoints for the group to be effective as well as a change-oriented rather than a status quo oriented agenda.	X			X				X	X	X

(TABLE CONTINUED ON NEXT PAGE)

TABLE 1: *Attributes and Actions of Mathematics Teacher Leaders* (*CONTINUED FROM PREVIOUS PAGE*)

#	Attribute	Action	Literature Support									
			Miles et al. (1988)	NCTM (1991)	O'Connor & Boles (1992)	Fullan (1995)	Miller et al. (2000)	NCTM (2000)	Katzenmeyer & Moller (2001)	Langbort (2001)	Lieberman & Miller (2004)	NBPTS (2005)
7	Believes all students can learn and all teachers can teach	Teacher encourages students to enter the teaching field. In order for all students to know they can learn, they must see mentors that have preceded them who have learned and succeeded. Teacher cultivates teachers from within the classroom and community. Teachers must work with other teachers in the belief that teaching practices can improve.								X		X
8	Advocate for students and teachers	Teacher attends meetings inside and outside schools and speaks up when actions proposed or taken negatively impact students and teachers.		X		X						X
9	Mathematics teacher ambassador	Teacher talks about practice in terms that individuals outside the classroom, school, and community can understand. Teacher addresses concerns of the public by talking about what teachers and students do.		X		X	X		X	X		
10	Understands political nature of classroom teaching	Teacher recognizes that every classroom move is political. Teacher reads more about political nature of classrooms (and larger school and educational field) and carefully observes how such politics play out.		X		X	X			X	X	
11	Capacity to create and execute action plans	Teacher develops an action plan when a need for change is observed. Detailed steps are laid out and possible roadblocks identified. Proposed strategies for overcoming those roadblocks before the action plan begins are included. Then, the action plan is executed and modified as the paper world meets the real world.					X		X			
12	Knows where to look for and secure funding	Teacher is knowledgeable about funding opportunities. Teacher leaders must be able to locate monies and funding agencies to support proposed plans. Teacher builds and modifies a list of funding sources. Teacher talks with colleagues, professional organizations, administrators, and business people to publicize and increase the list. Teacher helps other teachers find funding sources for projects.								X		
13	Takes risks	Teacher tries new projects. Teacher gives students the benefit of the doubt, opens up the classroom to parents, colleagues, and mathematics professors. Teacher asks students how instruction may be improved.								X	X	

Attributes & Actions to Improve Mathematics Teaching & Learning

In this section, I address the above attributes and what measures mathematics teacher leaders can take to help themselves and colleagues improve their teaching to create a mathematics reform classroom environment. I will use the phrase mathematics teacher leader at times and simply teacher leader at other times. It is important to note that I am always referring to a mathematics teacher leader, but do feel that many of these comments apply to teacher leaders in other content areas as well.

First, mathematics teacher leaders are called to be both mathematical content experts (attribute 1) and mathematical pedagogical content experts (attribute 2). Mathematics teacher leaders can mentor teachers in these areas, taking university classes as well as professional development courses together. As many researchers have noted (Barth, 2001; Fullan, 2002; Lieberman & Miller, 2004; Miller et al., 2000), teacher leadership (and I would argue teaching as well) happens in collaborative groups. I see the role of the teacher leader to be to learn alongside mentees and colleagues. For instance, novice teachers and teacher leaders could be a part of weekly curricular groups allowing both to learn more deeply about the curriculum.

Second, I see cultivating teacher leaders (attribute 3) as one of the most important attributes. Teacher leadership is about striving for the benefit of the entire organization rather than an individual (similar to Fullan's idea of moral purpose). One person can only teach or lead for so long. It is the responsibility of that teacher leader to mentor and develop other teacher leaders. They must share what they know in order for cultivation to occur. For instance, the year before a mathematics department chair steps down, she or he serves as a co-chair with the new department chair. As co-chairs, the new chair works alongside an experienced colleague while also bringing new ideas to the role. Much like the old adage that you learn better when you teach, I would offer that you learn to lead better when you teach others to lead.

Next, attributes 4 and 6 call teacher leaders to look objectively at their practice and be members of a learning community. Teacher leaders invite teachers into their classrooms to observe their teaching, talk about strengths, and offer suggestions for improvement. For instance, teachers who are a part of the same curricular groups (mentioned above for attributes 1 and 2) choose a similar lesson to observe each other teaching. During the next curricular group meeting, the focus would be to discuss what everyone observed. Once teacher leaders open their classroom for constructive criticism in a spirit of improvement and quality teaching for students, then other teachers will feel more comfortable opening their classrooms for the same practice. Teacher leadership is not about "fixing the broken;" it is about lifting up and improving all teaching practice.

Fourth, trust (attribute 5) is a foundational piece to teacher leadership (Miles et al., 1988) and I believe, one of the most difficult to develop. For instance, before curricular group members observe one another, they should have a conversation around the apprehensions members have about opening their classroom. Although at times discussing apprehensions may be uncomfortable, the teacher leader must pursue these conversations. As teachers may initially feel uncomfortable sharing fears, the teacher leader generates a list or has members type concerns to discuss anonymously. To invite colleagues into a classroom to watch a very public, however very personal practice, trust must be central to that relationship. Trust in the sense that the teacher leader is present to genuinely help a teacher improve instruction for professional development as well as for the development of the children's learning in that classroom. Trust comes in when teachers also recognize that teacher leaders are not only interested in improving others' practice, but also their own practice. This recognition returns to the idea that teacher leadership is about improving the organization as a whole rather than simply individuals (Fullan, 2005).

Fifth, teacher leaders must believe all students can learn and all teachers can teach (attribute 7), advocate for students and teachers (attribute 8), and serve as a mathematics teacher ambassador (attribute 9). In order for teacher leaders to persist in teaching all students and working with all teachers, the belief must be present that everyone is capable of improving. That belief also provides the stamina teacher leaders need to advocate when they feel their attempts are failing. For instance, when a teacher is struggling with a class, a teacher leader provides support by observing and, at times, being an additional presence in the classroom. If a policy is proposed that will impact students, a teacher leader talks with students about the policy to find out what students think and then shares students' thinking with colleagues and administrators. As a mathematics teacher ambassador, teacher leaders can explain to stakeholders outside of mathematics education the impact

changes may have on students and teachers. For instance, if a reform-based curriculum is introduced, a teacher leader talks with students, parents, and the community addressing questions and concerns using understandable language devoid of educational jargon.

Sixth, teacher leaders understand the political nature of the classroom (attribute 10), have the capacity to create and execute action plans (attribute 11), and know where to look for and secure funding (attribute 12). These three attributes affect one another. Understanding the political nature of the classroom impacts a teacher leader's ability to execute an action plan. At times, action plans require funding. The political nature of the classroom means teacher leaders foster crucial relationships with students, parents, community members, and administrators. Teacher leaders take great care when talking with others, choosing words wisely, knowing the potential impact of their statements. A teacher leader may develop an action plan to make departmental meetings more curricular based. The first department meeting is devoted to developing strategies and listing potential challenges in executing such a plan. The department revisits the action plan throughout the year to discuss its success and modify if necessary. If an action plan requires funding, a teacher leader has a list of potential sources. Teacher leaders build a list of potential funding resources, such as local professional organizations as well as more national organizations, such as NCSM and NCTM. Teacher leaders share lists of resources with colleagues.

Finally, teacher leaders take risks (attribute 13). These risks can be in the form of trying out a new curriculum, opening up the classroom for others to visit, critically investigating practice through teacher research, or candidly talking with students about how instruction may be improved. For instance, if students are struggling with a mathematical concept, a teacher leader talks with students, as well as colleagues, about a different instructional approach they think may be helpful and implements the instructional approach. Discussion and dialogue continue to evaluate how the approach is working. Another example of a teacher leader taking a risk may be to enroll in a course in an unfamiliar area of mathematics. The course may not only challenge the teacher intellectually, but also remind the teacher of how it feels to be a student of unfamiliar mathematics.

Concluding Remarks

In 1983, *A Nation at Risk* transformed education into a national agenda with a political nature. The Carnegie Task Force answered *A Nation at Risk* with the NBPTS and NCTM responded to the 1983 report with the *Professional Standards for Teaching Mathematics* (1991). Both documents outlined what teacher leaders should look like and do. Further research has expanded those initial attributes and will continue to do so. I have taken the present research and used it to inform my own list of attributes and actions creating a profile of a mathematics teacher leader and how those attributes can help teachers improve the reform mathematics environment in their classrooms. Without the guidance of effective mathematics teacher leaders, reform efforts will be difficult to implement. Teachers need to work together to fully recognize the power of reform efforts.

As the field of teacher leadership grows, future research will add to the existing literature, specifying the difference and unique attributes of teacher leaders in content areas, such as mathematics and science. Future research is needed to help translate current research into more profiles like the one above. Practicing teachers need to see teacher leader profiles in practitioner terms (translated from the research) to enable them to enact the attributes in their schools and classrooms. And finally, more research is needed to see how teacher leaders are affecting change in their schools and how, ultimately, that change translates into improved student achievement.

References

Barth, R.S. (2001). The teacher leader. *Phi Delta Kappan*, 82(6), pp. 443-449.

Carnegie Task Force on Teaching. (1986). *A nation prepared: Teachers for the 21st century.* Washington, DC: Author.

Dozier, T. (October, 2004). *Turning good teachers into great leaders.* PowerPoint presentation at the National Principals Forum, Washington, D.C.

Fullan, M. (1994). Teacher leadership: A failure to conceptualize. In D.R. Walling (Ed.), *Teachers as leaders: Perspectives on the professional development of teachers* (pp. 241-253). Bloomington, IN: Phi Delta Kappa Educational Foundation.

Fullan, M. (2002). Moral purpose writ large. *The school administrator.* The Association of School Administrators. Retrieved October 2, 2005, from http://staging.aasa.rd.net/ publications

Fullan, M. (2005). *Leading in a culture of change: Presentation to Wake County Public School System.* Raleigh, NC.

Hall, G.E. & Hord, S.M. (1987). *Change in schools: Facilitating the process.* New York: State University of New York Press.

Katzenmeyer, M. & Moller, G. (2001). *Awakening the sleeping giant: Helping teachers develop as leaders (2nd ed).* Thousand Oaks, CA: Corwin Press.

Langbort, C. (2001). The professional development of effective teacher leaders. In C.R. Nesbit, J.D. Wallace, D.K. Pugalee, A. Miller, & W.J. DiBiase (Eds.), *Developing teacher leaders: Professional development in science and mathematics* (pp. 245-266). Columbus, OH: ERIC Clearing house for Science, Mathematics, and Environmental Education. (ERIC Document Reproduction Services No. ED451031).

Lieberman, A. & Miller, L. (2004). *Teacher leadership.* San Francisco, CA: Wiley & Sons.

Loucks-Horsley, S. (1996). Professional development for science education: A critical and immediate challenge. In R. Bybee (Ed.), *National standards and the science curriculum.* Dubuque, IA: Kendall/Hunt Publishing.

Miles, M., Saxl, E., & Lieberman, A. (1988). What skills do educational "change agents" need? An empirical view. *Curriculum Inquiry,* 18(2), pp. 157-193.

Miller, B., Moon, J., & Elko, S. (2000). *Teacher leadership in mathematics and science: Casebook and facilitator's guide.* Portsmouth, NH: Heinemann.

National Board for Professional Teaching Standards. (2005). *About NBPTS: Five core propositions.* Retrieved December 22, 2005, from http://www.nbpts.org/about/coreprops.cfm

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform.* Washington, DC: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

O'Connor, K. & Boles, K. (April, 1992). *Assessing the needs of teacher leaders in Massachusetts.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA. (ERIC Document Reproduction Services No. ED348770).

Wasley, P. (1991). *Teachers who lead: The rhetoric and reform and the realities of practice.* New York, NY: Teachers College Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* Cambridge, England: Cambridge University Press.

York-Barr, J., & Duke, K. (2004). What do we know about teacher leadership? Findings from two decades of scholarship. *Review of Educational Research*, 74(3), pp. 255-317.

APPENDIX A

The Five Propositions of the National Board for Professional Teaching Standards

Proposition #1: Teachers are committed to students and their learning.

- Teachers recognize individual differences in their students and adjust their practice accordingly.
- Teachers have an understanding of how students develop and learn.
- Teachers treat students equitably.
- Teachers' mission extends beyond developing the cognitive capacity of their students.

Proposition #2: Teachers know the subjects they teach and how to teach those subjects to students.

- Teachers appreciate how knowledge in their subjects is created, organized and linked to other disciplines.
- Teachers command specialized knowledge of how to convey a subject to students.
- Teachers generate multiple paths to knowledge.

Proposition #3: Teachers are responsible for managing and monitoring student learning.

- Teachers call on multiple methods to meet their goals.
- Teachers orchestrate learning in group settings.
- Teachers place a premium on student engagement.
- Teachers regularly assess student progress.
- Teachers are mindful of their principal objectives.

Proposition #4: Teachers think systematically about their practice and learn from experience.

- Teachers are continually making difficult choices that test their judgment.
- Teachers seek the advice of others and draw on education research and scholarship to improve their practice.

P**roposition #5: Teachers are members of learning communities.**

- Teachers contribute to school effectiveness by collaborating with other professionals.
- Teachers work collaboratively with parents.
- Teachers take advantage of community resources. (NBPTS, 2005)

APPENDIX B

NCTM Professional Standards for Teaching Mathematics

Standards for Teaching Mathematics:

Standard 1 Worthwhile mathematical tasks
Standard 2 The teacher's role in discourse
Standard 3 Students' role in discourse
Standard 4 Tools for enhancing discourse
Standard 5 Learning environment
Standard 6 Analysis of teaching and learning

Standards for the Evaluation of the Teaching of Mathematics:

Standard 1 The evaluation cycle
Standard 2 Teachers as participants in evaluation
Standard 3 Sources of information
Standard 4 Mathematical concepts, procedures, and connections
Standard 5 Mathematics as problem solving, reasoning, and communication
Standard 6 Promoting mathematical disposition
Standard 7 Assessing students' understanding of mathematics
Standard 8 Learning environments

Standards for the Professional Development of Teachers of Mathematics:

Standard 1 Experiencing good mathematical teaching
Standard 2 Knowing mathematics and school mathematics
Standard 3 Knowing students as learners of mathematics
Standard 4 Knowing mathematical pedagogy
Standard 5 Developing as a teacher of mathematics
Standard 6 The teacher's role in professional development

Standards for the Support and Development of Mathematics Teachers and Teaching:

Standard 1 Responsibilities of policy makers in government, business, and industry
Standard 2 Responsibilities of schools and school systems
Standard 3 Responsibilities of colleges and universities
Standard 4 Professional organizations' responsibilities (NCTM, 1991)

NCSM Order/Membership Form

Use this form to renew a membership, join NCSM, update information, or order items. **You must be a member of NCSM in order to purchase any materials.** Fill out the following and return with credit card information or a check (U.S. funds). The information you provide will be used by the NCSM office for mailings, contacting you, and printing in our Membership Directory. Check the circle next to **ALL** the items you do **NOT** want printed in the Directory.

NCSM sometimes provides its mailing list to outside companies who may send catalogs, publications, announcements, ads, gifts, etc. Check here to remove your name from ALL mailing lists provided to outside companies. ☐

Circle One: Mr. Mrs. Ms. Miss Dr. Fr. Sr.

○ First Name _____ ○ Middle Name or Initial _____ ○ Last Name _____

○ Position _____ ○ Employer _____

This is my complete ☐ Home ☐ Work mailing address: ☐ Update ☐ Renewal ☐ New Member

○ Address line 1 _____ ○ Home Phone _____

○ Address line 2 _____ ○ Work Phone _____

○ City / State / Zip _____ ○ Fax _____

○ Country (if NOT United States) _____ ○ E-mail _____

Please check all that apply. I am a leader in mathematics education at the following levels:

☐ National	☐ University/College	☐ Author
☐ Regional (more than one state/province)	☐ Senior High School	☐ Consultant/Independent
☐ State/Province	☐ Junior High/Middle School	☐ Student
☐ District/County/City	☐ Elementary School	☐ Retired
☐ Building (teacher, principal, etc.)	☐ Publisher	☐ Other_____

Since designations vary over time, check the one you feel best describes you:

☐ African American/Black	☐ Hispanic/Latino	
☐ Asian American	☐ Native American	
☐ European American/White	☐ Pacific Islander	☐ Other_____

Check the area you serve:

☐ Rural ☐ Suburban ☐ Urban

Do you make purchasing decisions? ☐ Yes ☐ No

* **Postage/Handling**: Only Source Books require a payment for postage/handling: $4 each for 1-5 copies sent to destinations in the U.S. and Canada. Contact NCSM for a quote on larger orders and/or other destinations.

NCSM
9373 Prairie View Drive
Highlands Ranch, CO 80126
Fax/Phone 303-274-5932
ncsm@mathforum.org
www.ncsmonline.org

NCSM Tax ID: #39-1556438

Payment Method: ☐ Check/M.O. ☐ MasterCard ☐ Visa ***No P.O.'s***

Card # _____

Cardholder Name_____ Exp ____/____

Cardholder Signature_____

Qty.	Item (details online)	Unit Price	Total Price
___	Source Book: ***Great Tasks and More***	$25*	$_____
___	Source Book: ***Supporting Improvement***	$25*	$_____
___	Monograph: ***Future Basics***	$10	$_____
___	NCSM Member Pin	$2	$_____
	Merchandise Total		$_____
	* P/H: $4 each Source Book		$_____
___	**Year(s) of Dues**	**$75**	$_____
		TOTAL	$_____

Availability of products and prices subject to change without notice.

National Council of Supervisors of Mathematics
9373 S. Prairie View Drive
Highlands Ranch, CO 80126

Presorted Standard
U.S. Postage
PAID
Brockton, MA
Permit No. 301