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ABSTRACT

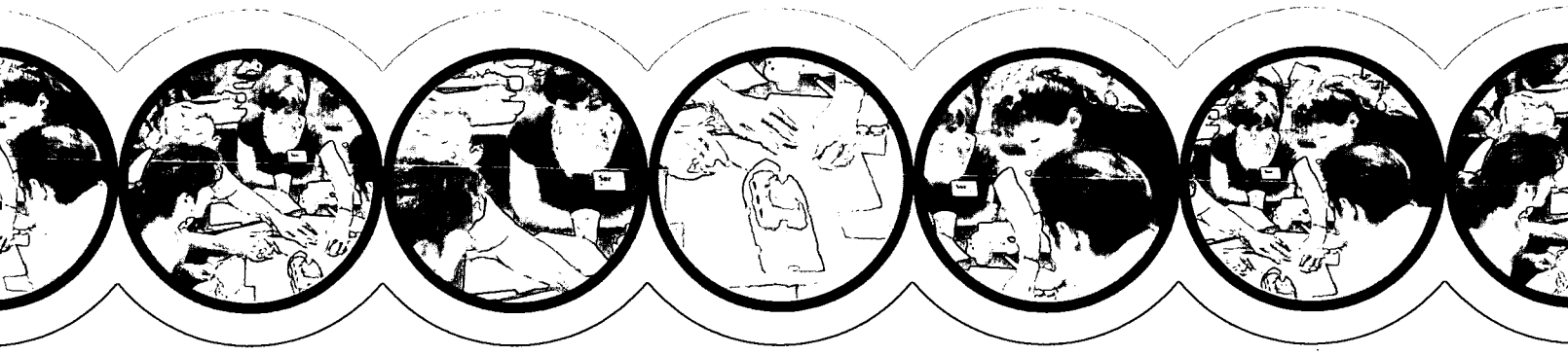
This report focuses on supporting professional development and presents research and its implications for mathematics and science reform to policymakers, educators, and researchers seeking to improve student learning and achievement. Topics include actions for administrators, new directions in instruction and professional development, the value of professional learning communities, and concerns about creating capacity for instructional reform. (KHR)

Supporting Professional Development & Teaching for Understanding--Actions for Administrators

Valerie Farnsworth

in Brief

K-12 Mathematics & Science
RESEARCH & IMPLICATIONS
FOR POLICYMAKERS, EDUCATORS & RESEARCHERS
SEEKING TO IMPROVE STUDENT LEARNING & ACHEIVEMENT



Supporting Professional Development & Teaching for Understanding —

Actions for Administrators

What factors contribute to a school's capacity to advance and sustain reforms? What resources and support systems do teachers need to achieve the instructional goals central to mathematics and science education reforms? How can schools and districts ensure a supportive context for teacher professional development, especially for teaching mathematics and science for understanding?

Such questions are at the core of a multiyear study conducted by sociologist Adam Gamoran and colleagues at the National Center for Improving Student Learning and Achievement in Mathematics and Science (NCISLA). NCISLA researchers closely examined the reform process in six design collaborative sites (see sidebar, p. 3) spanning 15 schools. In addition to showing how a school's organization and context influence the change process, the study characterizes high-capacity schools in terms of the elements that contribute to fostering and sustaining instructional change. The study provides a new model for thinking about resource allocation and leadership roles and suggests how schools and districts can support teachers as they change instruction to improve student learning and understanding in mathematics and science.

Looking Inside the "Black Box"

Traditionally, studies examining how resources influence student outcomes have treated schools as a "black box" – evaluating correlations between inputs (such as number of teachers or library resources) and outcomes (such as student achievement). Gamoran's study, building on research that examined the relationship between school organizational conditions and student learning (Newmann & Associates, 1996), proposes that –

- Resources flow through **multiple levels** of the school organization and in **multiple directions**.
- **Material, human, and social resources** each play a role in school and district efforts to support change (see sidebar , p. 3).
- Teacher **professional development** is an essential engine for change.

(See p. 2, Figure 1, Dynmic Model of Organizational Change)

The Research Project

The multiyear studies conducted by NCISLA researchers with partner schools in Wisconsin, Tennessee, and Massachusetts provided Gamoran and his team an ideal opportunity to examine a variety of organizational contexts in schools where significant instructional change and professional development occurred.

The researchers followed the progress of 102 teachers as they participated in professional development programs conducted over one to three years. From 1996 - 2000, the research team collected qualitative longitudinal data through 155 intensive teacher interviews, 42 district and school administrator interviews, and observations of 102 professional development seminars. In addition, the team collected approximately 500 survey questionnaires from mathematics and/or

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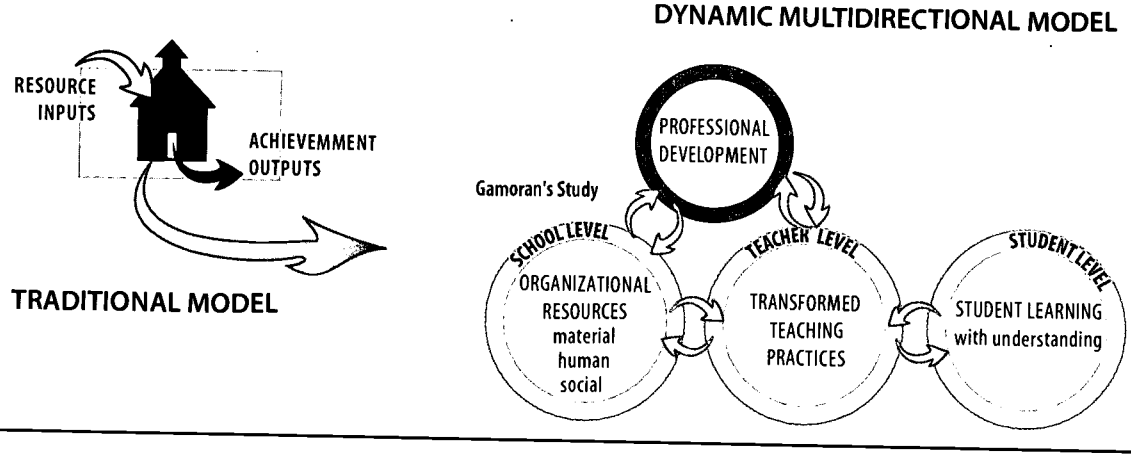
Figure 1. Traditional Model of Resource Use Compared to Dynamic Model of Organizational Change



science teachers at the collaborative sites[1], including teachers who did not participate in the design collaboratives. These data illuminated the context in which teachers implemented reforms in their classrooms and school communities, providing insights about teachers' needs, school characteristics, and supports for professional development.

All participating teachers were committed to changing their instruction. However, the sites differed in significant ways (see sidebar, p. 3, for details on collaboratives studied): in their specific reform goals, which were determined by the teachers; school type; reform context; location (suburban or urban); and school structure (such as grouping by departments or cross-disciplinary teams). Three of the collaboratives involved just one school, whereas others assembled teachers from several schools within a district. The student populations of the three urban districts were much more culturally and linguistically diverse than the three suburban districts, which had higher percentages of students who were white, spoke only English, and did not qualify for free- and reduced-lunch programs.

New Directions in Instruction and Professional Development

The instructional reform at these sites embodied an approach to teaching and learning encouraged by professional organizations such as the National Council of Teachers of Mathematics and the American Association for the Advancement of Science. The challenge of such reforms is to redesign science and mathematics curricula to meet the goal of "understanding for all." These reforms substantially alter the nature and demands of teaching. In this vision, students engage in scientific and mathematical reasoning as it is practiced in disciplinary communities. Teachers typically engage students in collectively exploring and explaining patterns in number and space, or explaining scientific phenomena. The goal is to foster students' understanding of key mathematical and scientific concepts as they engage in these activities. To meet these goals, teachers use their knowledge of their students' thinking—as well as content knowledge—to guide instructional decisions. (See previous NCISLA *in Briefs* about the ways *Elementary Students Learn Algebra With Understanding* and *High School Students Learn Science Through Scientific Modeling*.)

The professional development models used in these sites are unique in their focus on student thinking; they also emphasize building professional community. Through their involvement in the collaborative, the teachers increased human resources—as a result of learning and implementing new ideas—and built social resources through collaborating with one another. These professional communities, in which teachers shared and reflected on their practices and students' thinking, offered teachers a forum to develop ideas, identify ways to implement those ideas, and confront the challenges involved in changing their practice.

(See p.4, Teacher Voices: The Value of Professional Learning Communities.)

Findings

Viewing professional development as the engine of change, Gamoran and team identified features of school organizations that supported and/or impeded teachers' professional collaboration. The research reveals the need for new conceptions of resources and school leadership to support instructional reform.

Resources

Time. Teachers cited time as their most important resource. Most teachers considered time spent planning and learning with other teachers as most valuable. In all of the collaboratives, teachers and researchers met to discuss instructional strategies and activities that revealed student thinking. Teachers noted that this activity was vital to their growth and development as they worked to change their teaching practice.

Expertise. Teachers also considered collaboration with experts inside and outside the school as important to their growth. University researchers often provided this expertise. At one site, 63% of teachers said they would go to one of the researchers if they had a question about mathematics and science teaching. At some sites, teachers identified district officials and other teachers in the collaborative as important resources. In response to the question, "What resources have been helpful or important to you this year for supporting your science instruction?" one teacher said, "People that I work with. That resource is invaluable. I don't know

[1] *The particular contexts of Janus and Mimas made it impossible to collect useable sets of surveys from either of those sites. Response rates across all other sites ranged, over the years, from 66% to 86%.*

what I would do in another situation where I didn't have the experience of the other teachers to draw on for ideas . . . That resource for me is the one without which I would be floundering."

Teacher communities. A pre-established community of teachers was not essential for instructional reform. However, at sites where teachers already collaborated, their relationships laid the foundation for the professional development group, and university researchers served as a catalyst for a process that was already under way, fostering continued learning and expansion of the community. Some factors inhibited the formation of professional communities. For example, "Mimas" High was organized into cross-disciplinary "families" that separated mathematics teachers from one another and made subject-matter collaboration difficult. In addition, an informal division between bilingual and monolingual teachers presented a significant barrier to collaboration. Without an established community, the Mimas group could not draw on social resources that might have supported and sustained the professional development program beyond the first two years.

AN EXPANDED VIEW OF *Resources*

MATERIAL RESOURCES – things that can be bought, exchanged, disseminated, or shared (e.g., computers, teaching tools, time, compensation).

HUMAN RESOURCES – qualities of individuals that can be exchanged among groups of people (e.g., teachers' expertise, understanding of students' thinking, knowledge of content domains, insights about cultural and social aspects of classroom group interactions).

SOCIAL RESOURCES – attributes of roles, relationships, or methods of communication that are found within a group. Social resources, such as trust and collaboration, create a sense of community. They result from the exchange of human and material resources when individuals and groups negotiate common purposes and develop shared norms.

Leadership

Responsive resource allocation. Administrators whom teachers considered supportive of teaching for understanding were responsive to teachers' needs instead of attempting to focus or limit teachers' efforts. Instead of allocating resources as a means of constraining teachers' activities toward one instructional approach or another, these administrators allocated resources in response to directions that teachers identified. For example, a suburban principal in "Europa," WI, expressed his role as "a facilitator, someone who creates the environment where good teaching can take place and where decisions can be made in the best interests of kids." Responsive administrators also drew from human and material resources available outside the school, such as NCISLA researchers and district support.

Distributed leadership. At the sites where teachers were successful in changing their instructional practice, Gamoran and team found that leadership was distributed throughout the organization. Administrators who supported teaching for understanding did more than just get out of the way. They provided opportunities for teachers

Continued on page 7. . .

Professional Development Design Collaboratives

At the Massachusetts, Tennessee, and Wisconsin study sites, teachers and NCISLA researchers collaborated to examine how students learn mathematics and science with understanding and developed professional development around student thinking and content knowledge. Through the elementary, middle, and high school design collaboratives, researchers and teachers engaged in design experiments to analyze classroom activities and plan instruction. Through a cyclical research and development process, participants collaboratively developed and analyzed instructional materials and pedagogical techniques, adding to the body of research knowledge on teaching and learning, and strengthening teachers' practices. (The design experiment research methodology is outlined in Cobb, 2001.)

Collaborative Sites Studied (All names are pseudonyms.)

Callisto Elementary and Middle (MA)	Four urban K–8 schools	22 teachers and 2 lead researchers
Focused on teaching bilingual students science for understanding.		
Europa Elementary (WI)	Four suburban elementary schools	49 teachers and 2 lead researchers
Focused on teaching through scientific and mathematical modeling.		
Europa Middle School (WI)	One suburban middle school	12 teachers and 2 lead researchers
Developed a multigrade algebra curriculum using *Mathematics in Context* materials.		
Janus Middle (TN)	Four urban middle schools	7 teachers and 2 lead researchers
Proposed to develop a statistical unit. The project was cancelled because of competing district curriculum mandates.		
Mimas High (WI)	One urban high school	4 teachers and 1 lead researcher
Focused on bilingual students' thinking in algebra, based on materials from the *Connected Math* curriculum.		
Oberon High (WI)	One suburban high school	8 teachers and 1 lead researcher
Created a series of instructional units that emphasized modeling approaches to science.		

TEACHERS' VOICES: *The Value of Professional Learning Communities*

At five sites where professional development took place, teacher learning was clearly evident. Teachers discussed their learning and subsequent instructional changes in interviews, citing the importance of collaborating with colleagues. Following are some brief insights NCISLA researchers gleaned from teacher interviews.

A Shared Sense of Purpose and Focus on Student Thinking

After a full-day professional development workshop, the researcher described an interaction between a veteran teacher (Sara) and two teachers in their second year with the project. The observer noted, "In discussion with the small group [whose members had used a common activity in each of their classrooms], it emerged that Sara had a lot more information about children's thinking than the other teachers because she had interviewed the children. Sara explained that she carried out this exercise by taking kids into small groups of six at a time while the other 2/3 of her class were with the teacher's aide. . . Sara was clearly a resource for the other teachers. She was advising them on who to use the sheets with, for example. . . Sara also takes advice. She asked about first graders since some of the other teachers had more experience teaching first graders than she did." The shared activity allowed for a focused discussion regarding student thinking and learning in mathematics.

Collaborating on Ways to Improve Student Learning

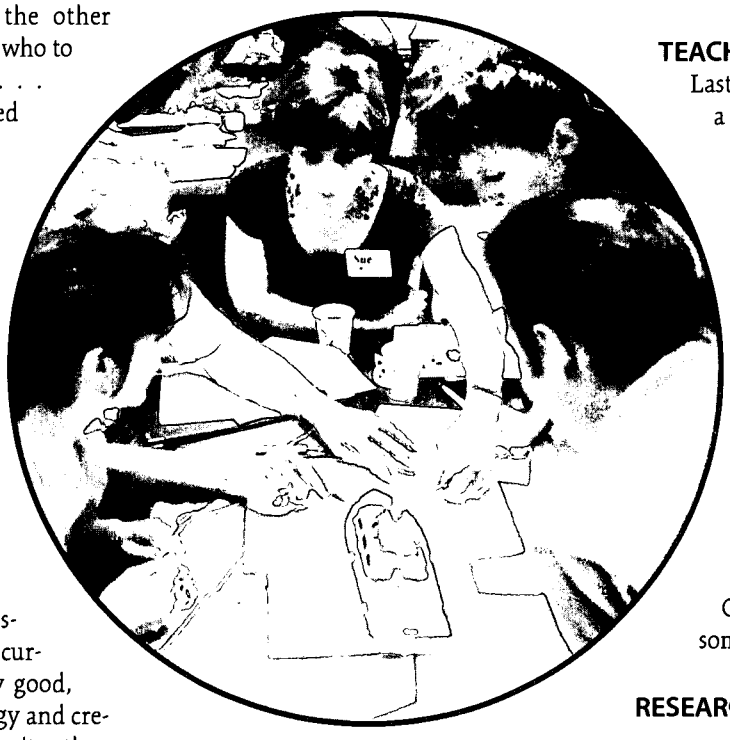
An Oberon suburban high school teacher discussed the value of collaboration: "I think [collaboration has] affected my classroom a great deal. I think writing curriculum with other people is very good, because no matter how much energy and creativity and background you put into it, other people always have other ideas as well. And that's what I love about working on a team, because you end up coming up with something better than [any] of the people could have done on their own . . . "

Making Teaching Practices Public

As part of the collaborative project, researchers observed the teachers in their classrooms and provided feedback. The following excerpt from a Europa suburban middle school collaborative meeting, at which the teachers discussed potential times for the researcher to observe their classrooms, illustrates the value of getting feedback and the ways teachers can draw on the human and social resources developed through their community:

TEACHER 1:
That's the main thing that you miss [from] student teaching. Bouncing ideas off of other people. It helps me to think about things.

TEACHER 2:
Last year, [the lead researchers] shared a lot with me. One of the biggest advantages of being in the project is having an extra adult and being able to share observations on what you did.



TEACHER 3:
Last year, there seemed to be a better balance. With a bigger group, it's harder.

RESEARCHER:
Last year, the number of teachers was equal to the number of researchers. [Now] with everyone doing teaching experiments, there are more teachers than researchers.

TEACHER 3:
Would it be possible to work together without researchers? Observing each other would in some ways be more valuable.

RESEARCHER: I agree whole-heartedly.

[Recognizing the limits of researchers' time to continue supporting teachers one-on-one, this researcher supported teachers combining available human and social resources and drawing on the expertise of colleagues to proceed in their learning and professional development.]

What Was Unique About These Learning Communities?

In contrast to teachers' usual practice of working in isolation and meeting primarily to discuss administrative details, these teachers collaborated, engaged in reflective dialogue that focused on student thinking, and made their teaching practices public.

inBrief

K-12 Mathematics & Science PRACTICAL CONSIDERATIONS

Creating Capacity for Instructional Reform

"A school with high capacity effectively deploys material, human, and social resources.

The most important use of material resources is to support teacher professional development, which also increases the capacity of the school to engage in and sustain reform.

Professional development, in effect, increases human and social resources..."

Adam Gamoran, *NCISCLA lead researcher*

There is no single way to foster successful school reform. However, administrators and teachers working together can increase a school's capacity for building powerful professional development and sustaining instructional change. Leveraging resources, expanding leadership roles, and making support for teacher professional development and learning communities a priority combine to enhance and sustain instructional change.

What Resources are Important for Supporting Instructional Reform?

This research suggests that time is the most important material resource. The study also highlights the importance of expanding notions of resources to include human and social resources, which are essential in establishing and sustaining a professional community in which teachers—[4]

- **Share** a sense of purpose.
- **Focus** collectively on student learning.
- **Collaborate** on ways to improve student learning.
- **Engage** in reflective dialogue on the nature and practice of teaching.
- **Make public** their own teaching practice.

[4] *Newmann and Associates (1996).*

Researcher Observations

Administrators will want to provide teachers with significant time for collaboration and professional development. For example, the teachers at these sites, on average, had one or two 2-hour meetings per month and engaged in intensive summer workshops. Although most teachers viewed curricular materials as less important than time, bilingual teachers tended to consider curricular materials equally as important because having to translate materials that were not in the language of instruction took up valuable time.

The use of prepackaged curricula was also a site-based decision. Only one of the sites used a prepackaged curriculum; others developed their own curricula as part of the collaborative process. Although the "from scratch" approach provided flexibility, it also left some teachers frustrated by the time spent on administrative issues during the curriculum-development process.

Ultimately, districts and schools with high capacity to support instructional change use their resources strategically to create new resources that foster change. For example, districts and schools that wish to enhance their capacity for change would do well to—

- **Increase** teachers' opportunities to meet.
- **Provide** an infusion of human resources by bringing in outside experts.
- **Allow** teachers autonomy to try new approaches in a supportive environment.

What Forms of Leadership Support Teachers' Professional Growth and Collaboration?

This study highlights forms of leadership that support teachers' professional development and collaboration. Specifically, leadership that supports change is responsive to teachers' expressed needs. When leadership is distributed across the organization and teachers and administrators collaborate on decision making, teacher-leaders emerge and professional communities grow. As Gamoran notes, "this requires administrators to rethink their roles from the director of activity to a facilitator – someone who draws connections, someone who makes linkages, someone who supports the initiatives that teachers are taking." With sufficient organizational support in place, teachers can grow professionally and eventually take on leadership roles that contribute to the capacity of the school.

An administrator wanting to support teachers in instructional change should—

- **Allocate** human and material resources based on teachers' input and the particular organizational context.
- **Distribute** leadership roles across the faculty to draw on and enhance in-school human and social resources. Establishing these informal leadership roles does not, however, eliminate the need for formal leadership in managing logistics.
- **Pay attention** to potential barriers that could constrain or inhibit community building. Examples of such barriers include cross-disciplinary "families," divisions between bilingual and monolingual teachers, or competing initiatives.

Researcher Observations

The researchers noted a potential problem associated with reliance on entrepreneurship to generate resources for teachers, suggesting some administrators might need to be more proactive in the allocation of resources. Novice teachers or those outside the networks failed to obtain resources they needed. Human resources, such as university researchers, were not always offered to bilingual teachers unless the program was district-wide. Administrators face a real challenge in wanting to be responsive to individual teacher commitment while also maintaining an equitable distribution of resources.

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K-12 Mathematics & Science PRACTICAL CONSIDERATIONS

Creating Capacity for Instructional Reform

How Can Schools Overcome Obstacles to Instructional Reform?

In many ways, the sites examined here faced challenges that schools across the nation commonly face. The new conception of resources and leadership offered here suggests ways some of these challenges can be addressed.

Tackle teacher turnover and administrative changes. Professional communities will inevitably lose key human resources over time. Sustaining change requires finding new ways to recruit and generate new human resources. Powerful professional development is one way of increasing human resources within a school or district. Ideally, teachers in a supportive context can maintain their professional development even after outside experts or leaders leave a school.

Tap untapped resources. When leaders evaluate a school's material, human, and social resources, they can identify not only what's missing, but also which untapped resources can be better utilized. For example, local universities or teachers in the vicinity of the school or district are commonly overlooked as potential resources. In addition, when resources are evaluated and allocated in response to articulated teacher needs, their positive impact can be magnified.

Promote professional development to meet standards. Standards play an important role in current educational reforms. The study shows how accountability and standards can become a resource for teachers' professional development, or a constraint to change. The type of professional development described here can provide teachers an opportunity to make sense of standards and collaborate on ways to implement them effectively. When teachers have adequate human, social, and material resources, they are more empowered to respond to state standards.

How Can School Leaders Better Sustain Instructional Reforms?

Sustainability is most likely when all four conditions—integration, linkage, organizational integrity, synergy (see p. 7)— are met. Administrators wishing to sustain reform would do well to—

- **Encourage professional communities** by establishing trust, mutual expectations, and shared values to enhance integration.
- **Develop linkages** with community resources that would contribute to teachers' professional development.
- **Enhance organizational integrity** by reducing the number of divergent instructional programs and rules that constrain the change process.
- **Inform key figures** outside the professional development group of what the group is producing and why it is valuable to ensure alignment of goals and to enhance synergy.

Researcher Observations

NCISLA researcher Tona Williams noted the importance of professional development for implementing state standards.

"I think there's a common conception that standards are much more transparent to implement than they actually are. And usually to really interpret them effectively and to implement them well, teachers need to be able to collaborate with each other and to figure out how exactly those standards can be translated for their particular students and the context of their particular school . . .

It really helps if that's done in a group context, and in cases where that's not possible. . . . teachers are more likely then to just follow whatever outline is given to them."

ADDITIONAL RESOURCES

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Transforming Teaching in Math and Science

HOW SCHOOLS AND DISTRICTS CAN SUPPORT CHANGE

by **Adam Gamoran, Charles W. Anderson, Pamela Anne Quiroz, Walter G. Secada, Tona Williams,** and **Scott Ashmann**

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to take on leadership roles, allocated resources in response to teachers' needs, and helped establish productive relationships among teachers. Through distributed leadership, teachers developed expertise that they shared with their colleagues in a supportive context. This helped establish a professional community and, importantly, generated new human and social resources. Gamoran explains that, "by investing resources in professional development, the resources are not used up but instead generate new resources. That's why we see professional development at the very center of the change process."

School and district contexts. The design collaboratives were embedded in school and district contexts that both helped and hindered the change process. For example, the Europa district's support for "circles of excellence" and innovation among teachers – combined with the elementary school's hiring flexibility and significant allocation of professional development time – positively supported instructional change. At times, school or district content-specific visions failed to align with the collaboratives' goals for teaching for understanding. At Janus, district goals that diverged from teaching for understanding, combined with strong accountability measures, pressured teachers to withdraw from the collaborative project.

At most sites, administrators advanced a more general vision, such as "all children can learn," and teachers at those sites reported high levels of classroom autonomy. However, this approach was problematic at Callisto, where the district supported teaching for understanding, but a broad range of divergent programs competed for teachers' time and energy. As a result, at Callisto teachers' efforts to pursue their interests in teaching for understanding were constrained. These findings illustrate how the interrelated components of a school context influence its capacity for change and the sustainability of teacher collaboration.

Community and Resource Building to Sustain Change

Teachers working to teach for understanding changed more than their classroom practice. In the ongoing partnerships, schools gained access to or created new human, material, and social resources, developed new styles of leadership, and formed professional communities. The infusion of these human and material resources enhanced social and professional ties that supported the change process and encouraged generative teacher professional development.[2] Although instructional change was evident at all five sites with established design collaboratives, sustaining that change proved to be a significant challenge.

Sustainability. Gamoran's research team was interested in the potential for sustainability at these sites and examined the following four qualities of professional communities[3]:

- **Integration.** Refers to trust, mutual expectations and shared values that form the social resources necessary for a learning community.
- **Linkage.** Refers to the connections between the professional community and the wider environment. This process allows members to draw in important material and human resources.
- **Organizational integrity.** Refers to the coherence, competence, and capacity of institutions to manage the change process. A school with high organizational integrity looks different from one in which rigid rules and procedures work to encourage members to follow standard routines. Such a school is also flexible and responsive to the change process.
- **Synergy.** Refers to the relations between efforts of the community that is trying to change and those of the organizations in its larger environment. This factor recognizes teachers' embeddedness in an environment of organizations and the importance of alignment of goals within that environment.

The analysis suggests that neither integration, linkage, organizational integrity, nor synergy are sufficient individually for maintaining generative teacher professional development and changes in practice. (For more about generative professional development, see Franke, Carpenter, Levi, & Fennema, 2001.) Rather, all four dimensions are intertwined, such that the lack of one can undercut another.

Next Steps

The research suggests three key steps to supporting teaching for understanding: teacher commitment to shared goals, responsive school systems, and improvement of the research base. Each of these steps depends on the participation of teachers, school administrators, and researchers. The development of professional communities supports the change process and can generate additional human and social resources. In this vision for teacher professional development, teachers contribute to their professional growth and to the capacity of the school–and they expand the research base through their investigations of the ways students learn with understanding.

Commitment to change requires a rethinking of the ways schools are organized to obtain, create, manage, and allocate these resources. (See **Practical Considerations** (p. 5-6) for ways school administrators can support instructional change). An awareness of the ways in which the four dimensions of sustainability relate to one another in various contexts may help other groups negotiate the change process in their school or district. Future research will need to address ways to create professional communities where none exist in order to lay a foundation for initiating change.

ADAM GAMORAN

AREAS OF EXPERTISE:

- school reform
- school organization and resources
- inequity in education
- curriculum tracking/ ability grouping

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[2] *Franke et al. (2001) further clarified that sustainability of change includes generativity of practice. Teachers whose practice is generative apply what they have learned in their professional development experiences and continually modify their practice as they learn more about the ways students think about mathematics and science content.*

[3] *These qualities are based on a framework originally developed by Woolcock (1997).*

For More Information

This issue of *in Brief* is based on research reported on in a forthcoming book, *Transforming Teaching in Math and Science: How Schools and Districts Can Support Change*, by Adam Gamoran, Charles W. Anderson, Pamela Anne Quiroz, Walter G. Secada, Tona Williams, and Scott Ashmann (Teachers College Press, in press). For additional publications by Adam Gamoran, see the NCISLA website at *http://www.wcer.wisc.edu/ncisla/publications*.

ABOUT *in Brief*

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NCISLA is a university-based research center focusing on K-12 mathematics and science education. Building on several years of research, Center researchers collaborate with schools and teachers to create and study instructional approaches that support and improve student learning and understanding of mathematics and science. Through research and development, the Center is identifying new professional development models and ways that schools can better support teacher professional development and student learning.

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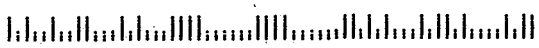

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