PRINCIPLED PRACTICE
In Mathematics & Science Education

NATIONAL CENTER FOR IMPROVING STUDENT LEARNING & ACHIEVEMENT IN MATHEMATICS & SCIENCE

FOCUS

Professional Development

FEATURES

ARTICLES

Teachers as Learners

BY THOMAS P. CARPENTER & MEGAN LOEF FRANKE

I equate this with a journey. The children have been my teacher as well as people at the university and fellow teachers . . . When you're on this journey there will be things that you as a teacher won't know, but you have to take a risk. You have to trust the kids. You do learn from the kids. You don't learn it in a week. You don't learn it in a workshop. You don't learn it in a month. You don't even learn it in a couple of years. You continually improve. I think good teachers always are learners . . . They have gotten hooked on how children learn and how they can best facilitate that learning, so they are always searching. That's what keeps teachers alive and vibrant, because they are always learning. You learn from kids, from fellow teachers, from the readings. You are always questioning. How can I be better? How can I be better, so my students are better? When you really start looking at kids, you see all the challenges.

Mazie Jenkins, Teacher
Madison, Wisconsin

Knowledge in the fields of science and mathematics is expanding at an accelerating pace. To prepare students for this rapidly changing world, teachers must become ongoing learners, both with their colleagues in professional communities and with their own students inside the classroom. Just as students can no longer simply learn fixed bodies of knowledge or static skills, teachers can no longer rely only on a fixed set of teaching skills or the use of a particular program of instruction. Teachers must begin to engage in inquiry as a fundamental part of their teaching practice.

(continued...)

(...continued)

The kinds of instruction envisioned in current reform recommendations and described in previous editions of this newsletter require new conceptions of teacher professional development that move beyond traditional training/coaching models. The shift in terminology from *teacher training* to *professional development* reflects this change.

Because we envision teachers as active participants in their own continued growth and problem solving, we conceive of teacher professional development in the same way we think about student learning for understanding—as the acquisition of knowledge, both for its practical application to real-world problems (in this case, in the classroom) and as the foundation for the acquisition of new knowledge. Such professional development supports teachers as they make changes in their fundamental conceptions of learning, teaching, and their role as teachers, shifting their focus to a deeper understanding of students' scientific and mathematical thinking and strategies.

Traditional teacher-training programs based on the process–product paradigm focused on training teachers to implement specific instructional practices or curricula. The professional-development programs currently being implemented and studied by NCISLA researchers shift the emphasis from teacher behavior to student thinking. Rather than training teachers to implement specific practices, a primary focus is on helping teachers construct a deeper understanding of students' mathematical and scientific thinking. Focusing on student thinking provides a natural basis for teachers to engage in inquiry that can serve as a basis for their ongoing learning. We describe the results of a study of one such program.

FOCUS ON STUDENT THINKING: LONG-TERM TEACHER CHANGE

A study we recently completed investigated the long-term effects of Cognitively Guided Instruction (CGI, Franke, Carpenter, Levi, & Fennema, 1998). CGI focuses on helping teachers develop explicit models of the development of children's mathematical thinking. The 22 teachers participating in the study were observed teaching mathematics and interviewed about their beliefs, practices, and perceptions of the ways in which they had changed since the program ended four years earlier. The study assessed whether the teachers' practices and beliefs had been sustained over the four years since the program ended and whether the program had provided a basis for continued growth. More critically, the study attempted to understand what accounted for change being sustained or not, and under what conditions change became generative.

A critical problem with traditional teacher training is that even in cases in which teachers learned to implement a particular practice, the fidelity of the implementation tended to erode over time. We found that focusing on student thinking provided a context in which teaching practices could become self-sustaining. All of the teachers in the study continued to attend to student thinking at some level. In order for change to become self-sustaining, teachers had to engage in practices that had built-in support for the changes they made. When teachers began to focus on students' thinking and allowed their students to discuss alternative approaches for solving a mathematics problem, the teachers often observed that students could generate a variety of productive, interesting, and unexpected solutions. These discussions supported teachers as they allowed students to generate and discuss their own solutions to problems.

We found, however, that if teachers simply listened to their students and did not take a more active role in developing understanding of their students' thinking, their practices might be sustained over time, but the teachers did not continue to learn and grow. For practice to serve as a basis for continued growth, a teacher had to struggle to understand the nature and effects of his or her own learning process. Simply observing that a practice was effective was not sufficient. For example, if a teacher tried out a particular practice and noticed that the practice "worked"—the children responded appropriately to the task—the teacher sometimes decided that the practice was worthwhile and should be continued. This sometimes encouraged teachers to use new techniques or activities, but it did not allow them to understand why the practice worked and what conditions were necessary and sufficient for success.

When teachers knew only that a practice worked, they could only implement the practice. Adapting the practice or instituting a similar practice in a new context, however, could prove difficult. It was in developing an understanding of their practices in relation to their students' learning that teachers developed the understanding necessary to generate new ideas. If a teacher struggled to understand why students were successful, how they were solving problems, how their thinking developed, and how instruction sometimes helped students to build on their current conceptions, connections were made, understanding developed, and the potential for more connections became possible. As a consequence, the teacher had a base from which to learn and continue to grow. This is reflected in the following quote from a second-grade teacher:

> *Every time you interact with a child, you're gaining more knowledge of how to interact with other children. Every time they show you, and tell you, what they're doing and thinking, you just learn more about what's going on in their heads.*

We found that three related features characterized teachers whose learning became generative: (a) teachers focused on constructing and elaborating coherent frameworks for characterizing the development of children's thinking, (b) they had detailed, explicit knowledge about the strategies their children used to solve problems, and (c) they perceived that they had an active role in constructing knowledge about student thinking and engaged in practical inquiry to elaborate their understanding of children's thinking. We also found that teachers whose learning became generative participated in communities that supported their ongoing learning. These findings have potentially important implications for the design of professional-development programs, which we are continuing to study *(see the following article)*.

MEGAN LOEF FRANKE: Professional Development & Mathematical Understanding

ANNE TURNBAUGH LOCKWOOD

Megan Loef Franke, an assistant professor at the UCLA Graduate School of Education and Information Studies, examines students' mathematical learning, along with teachers' knowledge, beliefs, and practice within the context of classrooms and schools. Drawing on 12 years of studying teachers within the Cognitively Guided Instruction project, she focuses on conceptualizing, studying, and creating opportunities for teachers' self-sustaining, generative change.

"If we want to improve what children learn in school," Megan Franke says, "there is a large body of research that shows that what the teacher knows and understands makes a tremendous difference."

Although this may sound like common sense, ongoing professional development for teachers too often places teachers in exactly the same roles education reformers decry for students: passive recipients of information disconnected from real-world problems and applied work situations. Franke makes a compelling argument that substantive, provocative professional development that treats teachers as active learners—working to increase their understanding of how their students learn and problem-solve—is nothing less than an imperative if students are to improve both the content and quality of what they learn.

Traditional professional development, as seen in many schools, may be well intentioned, but simply doesn't equip staff to probe their students' problem-solving or study their ongoing intellectual development. "The difficulty with professional development as it is often conceived," Franke explains, "is that it is thought of as something that has a start and end date. Instead, we have to change the way we think about teaching and about teachers."

As a professor, researcher, and professional developer, Franke has a task somewhat unusual to those in the university community: working actively with teachers to spur their understanding of student learning, yet encouraging their own development as ongoing learners. When she considers her own goals when working with teachers to advance their own knowledge, she sees a paramount—and crystalline clear—goal. "The primary goal of my research," she says, "is to engage teachers in professional development that focuses on their ongoing learning in the context of their practice."

This context is something that Franke underscores repeatedly. "We are beginning to understand how important it is for teachers to see their classrooms as places where they can learn," she emphasizes. "After all, they spend a tremendous amount of time with their students in those classrooms. Rather than thinking

(continued...)

(...continued)

about professional development as something that happens *outside* their classrooms, they should think about professional development as a part of the teaching that they do *in* their classrooms every single day."

PROFESSIONAL DEVELOPMENT: THE PROCESS

This integration of professional development into daily classroom work is the steady theme that informs Franke's interactions with teachers in her research on professional development. "I work with K–5 teachers in work groups," she explains. "All teachers pose the same mathematical task or problem to their students—one problem per month."

Although teachers can alter the problem to match what they believe is important for their students, they cannot change the fundamental structure of the problem. After receiving student responses, teachers return to their work groups to discuss and reflect upon what they have gathered.

"They share what they learned about how their students responded to the problem, the strategies that they used, and the ways in which they thought about the problem," Franke says. "We then list all the different ways that the children at these different grade levels thought about and solved this type of problem. We discuss which strategies are more sophisticated, why we think they are more sophisticated, and what we think as a group the children's developmental trajectory looks like."

This is not the typical content of professional development, Franke underscores. Rather than sitting through workshops on topics with little relationship to the daily work of their classrooms, or left to grapple with new concepts on their own once an in-service ends, these teachers assume substantive roles as researchers in their own classrooms. "Teachers work to create some framework for understanding what one might expect students to do," Franke points out, "so that we have a

JENNIFER SCHEXNAYDER: *Teaching Mathematics for Understanding*

ANNE TURNBAUGH LOCKWOOD

Jennifer Schexnayder, a former fourth/fifth grade teacher at Jefferson Elementary School in Lennox, California, was vexed when she saw her students achieve only a superficial understanding of mathematical problems and solutions. After her participation in Megan Loef Franke's research on professional development through the tenets of Cognitively Guided Instruction (CGI), Schexnayder saw different possibilities for students.

She herself was challenged, because the shift from traditional, didactic mathematics instruction to a focus on deeper understanding was not easy. "I had to think hard about what I knew, figure out where that would fit, and calculate what the next step would be," she points out. "I constantly had to ask myself: What would be the next good question to ask them to take students to a higher level of understanding?"

Her involvement in Franke's research nudged her own thinking about mathematics to a higher level. "While I might have understood mathematics in my own way, now I had to understand it in my students' way of thinking about it. If I saw how they understood it, then I could figure out the next piece to add to their understanding to take them to the bigger picture and really solidify their understanding."

Although her work as a teacher became more difficult and exerted a new set of intellectual demands, it also carried distinct rewards, she reports. "I was constantly growing," Schexnayder says.

Perhaps most profoundly, her understanding of her students will never be what it was prior to the professional-development experience. "I learned," she adds, "to let students think."

Learning how students think about mathematical problems and solutions bore unusual fruit, Schexnayder notes. "I taught math thematically. In a unit on pioneers, for example, I would take a true contextual problem of pioneers that involved numbers. One problem was: How much could you, as a pioneer, fit into a covered wagon? It was difficult.

"But the kids weren't discouraged," she continues. "They knew they could draw the wagons, they knew they could calculate it, they knew they could figure it out."

Students gained confidence about their own problem-solving abilities, even though problems might be difficult. "That does much more for them," Schexnayder points out, "than just spouting answers. They are willing to take on almost anything."

Schexnayder is very proud of this particular outcome. "They had the mentality that said: I can do anything," she concludes, "and I am going to prove to you that I can do this."

For a more detailed explication of Schexnayder's experience, see *Transforming Education for Hispanic Youth* by Anne Turnbaugh Lock-wood and Walter G. Secada (in press), U.S. Department of Education, Washington, DC.

notion of where students are moving in their understanding."

Cross-grade groupings of teachers, K–5, help teachers acquire a sense of students' development, she adds. "Teachers begin to see where children might go in their mathematical understanding. Fifth-grade teachers also get the opportunity to see kindergarten students who haven't been taught any formal mathematics solve problems in ways that their fifth graders don't solve problems."

The discussion that results among teachers, she says, provokes a type of questioning about student learning often absent in conventional classrooms. "Teachers begin to wonder what might have happened had they changed the problem," Franke explains. "They start to think about themselves as engaging and experimenting with their class to better understand their children's thinking."

This type of professional development has strong carryover into the classroom, she adds. When teachers return to their classrooms, they begin to experiment with problems because they begin to believe that the information they receive will help them with larger issues concerning how children understand and learn mathematics.

The professional development in which Franke is engaged provides an opportunity for teachers to discuss such issues, she notes, and also reflect on what they themselves have learned: "We ask: What do you know now that you didn't know before? How did this help you think about your teaching of mathematics?"

Franke says the task for professional developers is then to push teachers to develop connections between new ideas and the context of what they will do with them in their classrooms the next day or the next week. "It's very different," she emphasizes, "from attending an institute or workshop where ideas are presented but there is no follow-up that helps teachers apply these ideas once they return to their classrooms."

This type of professional development instead has a remarkable focus, she adds, that bears striking results: "Teachers say: 'We're learning all the time.' Every time they go back into the classroom they learn more and think more."

And rather than engaging in a set of mechanical activities estranged from daily practice, teachers report that they see this type of professional development as "immediately useful," Franke reports.

TEACHERS' VARYING LEVELS OF ENGAGEMENT

As teachers engage in such substantive development of their own thinking, their own responses vary in depth and quality. Franke has found that teachers bring with them varying levels of comfort and expertise about mathematics—along with heavy baggage of unhappy personal experiences that take time to unravel and set straight.

"Some teachers already have some exposure to knowledge about the development of children's thinking," she says. "It isn't foreign to them to ask their students how they solve a problem and to get some sense of what their children had done."

Other teachers, however, begin the professional development with little to discuss—other than whether their students got a "right" or "wrong" answer. "Since all they had to share were the answers that students gave," she says, "that showed the way they think about the teaching and learning of mathematics. Other teachers already were very good at listening to their children's thinking on other content areas. They took those skills and used them to listen to their mathematical thinking. These are the teachers who engaged immediately in question-asking, experimenting, and subtly changing problems to see what their children would do."

These teachers, Franke adds, are also the ones who listen carefully to the ways in which their students thought about problems: "We have teachers who don't ask their students how they solved the problem. We also have teachers who pose a problem but then interject and tell students how to solve it. Many of these teachers come to a realization as they work with us that they need to pose the problem and let children solve it."

This variety of teacher approaches and responses to the professional development, she says, only serves to enrich the experience. "Some teachers are much more willing to experiment than others," she points out. "Other teachers might pose a problem to their students but not really think much about it until the next work-group meeting. All of these factors clearly influence what they will learn."

DEVELOPING TEACHER COMFORT WITH MATHEMATICS

One of the areas that Franke is studying is the difficulty presented by the different levels of expertise elementary-school teachers have with mathematics. "I've worked with first-grade teachers who weren't comfortable with their own knowledge of the content," she says, "which made it very difficult for them to understand what their children were doing."

But exploring how children think about mathematics offers all teachers, Franke emphasizes, a nonthreatening means to discuss content without having to admit their own limitations of understanding before they are ready. "We get into conversations that have a lot to do with mathematical content," she says, "but teachers don't have to say that they don't understand the content . . . a teacher can say, very legitimately, that she or he is really curious about the child's thinking. Or a teacher can say: 'My student did this, and I don't really understand what it means.'"

Halfway through the year, teachers usually feel comfortable expressing their own limitations, Franke adds, "but it's very difficult to do that at the beginning of any professional-development experience. Focusing on children's

(continued...)

(...continued)

thinking provides an avenue for those who don't understand the content to get into substantive conversations about content in a very nonthreatening way."

TEACHERS AS RESEARCHERS

Ongoing professional development that focuses on helping teachers understand how children think and problem-solve, Franke says, gives teachers a sense of ownership of their own knowledge. "Rather than giving them readings on the development of children's thinking," she says, "I first suggest that they talk to their students, find out how they're thinking about these problems, and return to discuss what they've discovered.

"That makes the knowledge theirs," she adds. "The knowledge is about their kids. They find out about it, they bring it back to the group. After we've done that for about a year, I then give them readings which take on a whole new meaning for them. They see how they connect to what they saw their students do the previous year."

BUILDING RELATIONSHIPS THROUGH PROFESSIONAL DEVELOPMENT

Although Franke admits that the task of being both a researcher actively engaged in professional development that prods teachers to achieve their own potential as learners is stimulating and rewarding, it presents both theoretical and practical challenges. One key, she believes, is found in the ways in which professional relationships are built, developed, and nurtured between adults—much as master teachers work adroitly with their students to personalize the educational experience.

"Much of professional development as I do it," Franke reflects, "has to do with building relationships. We need to feel comfortable with each other so that I can push them a little bit. This takes time. It isn't the type of professional development that can be done in a very short amount of time. That becomes difficult."

Another focus of her research is understanding the individual contexts within which teachers work—as well as understanding how their students think about and understand mathematics. "I need to learn about their classrooms and the children in their classrooms," she points out, "so that when they talk in the work group I understand what they mean. It is time well-spent, because the payoff is great."

Franke's earlier work with Cognitively Guided Instruction (CGI) has provided the foundation for her current work, she says—and the two are clearly related. "We learned in the CGI work," she recalls, "that there are teachers who become generative in their change. I've tried to take the characteristics of those generative teachers and design professional development that lends itself to the development of those characteristics."

One critical characteristic is the ownership of knowledge, she emphasizes. "This is not my knowledge—it is their knowledge. Instead of giving teachers materials to read at the beginning about the development of children's thinking, I say: 'Go talk to your kids. Find out what they're thinking about these problems. Come back and we'll talk about it.'"

This makes the knowledge teachers are acquiring immediately their own, she points out. "It's about their kids. They find out about it, and they bring it back to the group."

After a year, she does provide research-based readings for the teachers she works with. "They then say to me, 'Now I see how these readings fit with everything I saw my kids do last year.' Again, what I want them to see is that it's not my knowledge and it's not outside, research-based knowledge. It's their knowledge."

To Franke, this is a critical difference, and one that characterizes generative teachers. "Teachers who become generative have frameworks for thinking about the ways in which their children think. This is the reason we always ask at the end of every work group: 'What do you know now?'

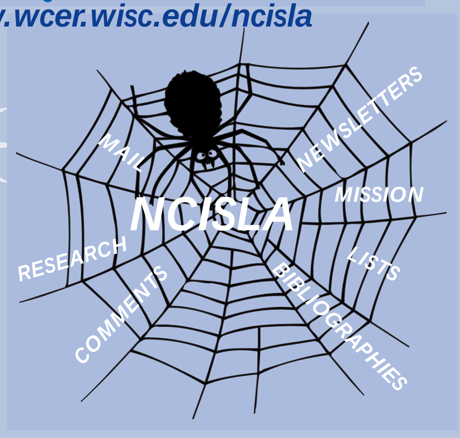
"This question helps teachers articulate the frameworks that they have as well as build them as they work with their students. We push teachers very hard to be as specific and detailed as they can as we write down children's strategies for the group."

The goal, she concludes, is transparently simple and exquisitely difficult at the same time. "We are helping teachers become ongoing learners," she says with care, "rather than handing them knowledge and saying: Learn it."

What's Up On the Web?

http://www.wcer.wisc.edu/ncisla

NEW!



Prepared statement for Presidential Meeting on Mathematics & Science Education
by Walter G. Secada

ANN S. ROSEBERY & BETH WARREN: Professional Development & Scientific Discourse

ANNE TURNBAUGH LOCKWOOD

Ann S. Rosebery and Beth Warren's research focuses on designing and analyzing classroom practices that support immigrant and bilingual students' learning of scientific discourses. Their focus is on students' learning in two domains, motion and evolutionary biology, and on students' learning of scientific practices of argumentation embedded in various forms of experimentation. In particular, they are examining the ways in which contact between students' everyday discourses and those of science is negotiated and used by both teachers and students in constructing scientific meanings (e.g., artificial and natural selection; variation; population thinking; inheritance; speed, time, and distance relationships; acceleration; inertia; forces) and practices (e.g., experimenting, graphing, constructing evidence, arguing scientific claims).

Beth Warren is co-director of the Chèche Konnen Center, the mission of which is to enhance, through inquiry-based teacher professional development, educational opportunities in science and mathematics for children from diverse cultures and language communities. For the past 10 years, in collaboration with other researchers and teachers, she has explored the varied ways in which immigrant and bilingual children make sense of the natural world and the deep connections of their ways of knowing to those of science. This work has been grounded in teacher research as a model of professional practice that integrates inquiry in science with inquiry into children's ways of knowing.

Ann S. Rosebery is co-director of the Chèche Konnen Center, a national NSF-funded center for improving science education for students from diverse cultural and linguistic backgrounds. Her current research interests include exploring science as a historically and culturally constituted practice and the implications this has for science teaching and learning, and developing models of teacher education that put teachers' theories and questions about learning and teaching at the heart of their professional development.

When Ann Rosebery and Beth Warren began their research on professional development with teachers of English-language learners, one of the first things they noticed was the discomfort many elementary-school teachers felt with science. This uneasiness was pronounced, Warren and Rosebery say—and a clear influence on the quality and content of teachers' instruction. It also limited the substance and range of classroom discussion about scientific ideas and phenomena, whether discussions were in English or in the students' first language.

Elementary-school teachers, Rosebery explains, frequently feel out of place in science. "They often opt to teach because they love language arts, literature, or writing—but are not comfortable in science," she says. "But currently their school districts, curriculum frameworks, or even the national standards demand that they teach a rigorous science curriculum for all students."

To compound the difficulty for teachers of English-language learners, these internal and external mandates usually do not offer anything that supports teaching children who may have limited experience with science and with school in general—and more layers of complexity are added when teachers are exhorted to teach science in an inquiry manner.

Rosebery adds, "Teachers frequently don't know what that means, and they're looking for help."

For those reasons, teachers may enter into Rosebery and Warren's research program with a limited set of expectations for professional development based on previous experiences. They may believe, Rosebery and Warren point out, that they will be walked through a structured set of curriculum materials or handed a potpourri of strategies for using sheltered English to teach science.

But this is not the goal of their project, they emphasize—and quickly teachers begin to see that this is a different kind of professional-develop-

(continued...)

(...continued)

ment experience. Instead, Rosebery explains, "Teachers become science learners themselves not only to become comfortable teaching a given curriculum, but also so that they will understand what it means to learn and understand science."

LEARNING AND TEACHING SCIENCE WITH UNDERSTANDING

Rosebery and Warren focus not on a specific set of solutions to scientific problems, but target students' discourse in science—their ideas, questions, explanations, and arguments. "The job of the teacher," Rosebery notes, "is to take the ideas that the kids bring with them into science class, building bridges between what the kids are thinking and the ideas and practices of science—and in that way build a science community within the classroom."

Over time, she emphasizes, teachers arrive at a broader understanding of science as a discipline. "They see science as a place where one asks certain kinds of questions and tries to answer them. This is particularly important because teachers have usually experienced science as something that is about other people's questions, not their own. In the process, they come to respect themselves and their children intellectually."

THE VALUE OF CLASSROOM DISCOURSE

The conversation that develops in the science classrooms of participant teachers depends, Warren adds, on teachers and students alike coming to share a sense of what it means to "talk science" with one another. "So much of traditional classroom talk consists of teacher questions, student answers, and teacher evaluations of those answers," she explains.

"As teachers are immersed in their own extended conversations in science with other adult learners in our professional-development seminar," Warren continues, "and as they view classroom videotapes from their own classrooms, they begin to see teaching and learning in new ways. A new importance is placed on discourse in the classroom—not just any kind of talk, but specific kinds of talk—theorizing and arguing claims, for example—focused on constructing scientific knowledge. New conversational spaces open up in these classrooms."

Both researchers report that teachers not only experience science in a non-threatening way through this type of professional development, but are deeply engaged and substantively challenged by the process. "We see teachers developing depth in their own understanding," Warren adds, "when they start to extend science to become a part of their own lives. That, to us, is one of the most powerful effects of this work."

Rosebery agrees: "We've worked with teachers who will say to us: 'I was doing the dishes last night and started thinking about buoyancy.' Or: 'My husband and I had a big argument about how a ball rolls down a ramp.' What they are learning and understanding about science becomes a part of their everyday intellectual life. They began to think about their students and classroom practice in the same way. This is a wonderful type of feedback for us, because it shows they are really engaged."

EXPLORING CLASSROOM PRACTICES

Because Rosebery and Warren collaborate with teachers who work with students from widely diverse backgrounds, they see additional depth of understanding develop when teachers begin to infuse their own learning experiences into their teaching and when they begin to question previously taken-for-granted practices. "Some of our teachers are Haitian, some are Latina, some are Korean," Rosebery explains. "They have been in situations themselves as schoolchildren

• • • CENTER MISSION • • •

The Center's mission is to craft, implement in schools, and validate a set of principles for designing classrooms that promote student understanding in mathematics and science.

To achieve this mission, we are conducting a sustained program of research and development in school classrooms in collaboration with school staffs to do the following:

1. *Identify a set of design principles.*
2. *Demonstrate, **in classrooms**, the impact of the design principles on student achievement.*
3. *Clarify how schools can be organized to support teaching for understanding.*
4. *Develop a theory of instruction related to teaching for understanding.*
5. *Find ways to provide both information and procedures for policymakers, school administrators, and teachers so they can use our findings to create, and sustain, classrooms that promote student understanding.*

MARY DISCHINO: Teaching Science With Understanding

ANNE TURNBAUGH LOCKWOOD

At the time that Mary DiSchino, a third/fourth grade teacher at The Graham and Park Alternative Public School in Cambridge, MA, became involved in Ann S. Rosebery and Beth Warren's professional-development research project, she reports she was plagued by a sense of dissatisfaction with her own teaching. "I was looking for meaning," she says. "I was asking: What am I doing with these kids? How can I really affect their learning? Why do I have to make them do things that make no sense?"

As she continued her own development as a teacher through her continuing education outside school, she couldn't rid herself of the perception that no matter how she tried, she wasn't being as effective as she could be in the classroom. The seeds of her later participation in the Rosebery/Warren research began when DiSchino decided to become involved in an MIT project conducted by researcher Eleanor Duckworth.

"Her moon-watching course of study intrigued me," DiSchino reports. "Suddenly I figured out why the earth is tilted, what it means when the moon is full, and when it's waxing and waning. But I wondered if I had the courage to change what I had been doing as a teacher."

As she worked with Rosebery and Warren, she began to engage more deeply with science. "The first year of our project was on our own science explorations," she recollects, "and the second year we talked about videotaping our classrooms."

The videotaping was revelatory to DiSchino. "My students and I were investigating why the days get shorter in the autumn," she remembers, "and kids were learning all sorts of things through asking one another questions. They learned about the globe, about longitude and latitude, the temperate zone, and the torrid zone."

Watching videotapes of herself in action in her own classroom was enormously helpful, she notes—and very revealing of ways in which she needed to adjust her teaching. "I would study the tapes and think about where I wanted to go next," DiSchino says, "what the conversation might be, where I wanted to guide it. Today, this is the way I teach science."

Her teaching changed in a profound way, she emphasizes, as she began to think of herself as someone actively engaged in understanding and participating in scientific projects with her students. "I didn't avoid science any more," she says. "In the past, while I might not have avoided it, I wasn't eager to get to it. Now it is a big part of my work with kids. . . . The other big change was I got the courage to try to help my students understand science in the ways I was helped to understand when I learned about the moon."

Her involvement in Rosebery and Warren's research on professional development, she says, has yet another benefit. "Unlike any other professional development I've experienced, they have an unlimited respect for the work of teachers."

where a teacher has taken what they have said and transformed its meaning."

One common way in which this can occur is when a teacher paraphrases what a student says in the classroom, the researchers report. This para-phrasing—although intended to be helpful—can constrain classroom conversation and silence English-language learners who are beginning to engage in scientific inquiry.

"We worked with a group of teachers who studied a classroom transcript brought in by an ESL [English as a Second Language] teacher who was working with a group of Latino youngsters as they explored seed germination and plant growth," Rosebery says. "As an ESL teacher, she assumed that she should take the phrases that the children used and elaborate upon them. If their English wasn't correct, she corrected it, thereby providing a model of good spoken English for the children."

But as these teachers looked at the transcript from this class, they began to question whether the teacher was instead changing the meaning of what her students were saying. "The second issue they began to discuss was whether the teacher was inhibiting the students from expressing their own ideas," Rosebery says.

"The more the teacher took over, appropriating and changing the children's words," she continues, "the less these words actually belonged to the children. The teachers in the seminar began to ask each other: What is the effect not only on the children's willingness to speak, but on their willingness to listen to each other and also to pursue their own ideas in science?"

The participating teachers did not emerge from their discussion with a definitive answer about the value of paraphrasing for ESL learners, which in any case is a complex issue, Warren adds, but they began to reach a deeper understanding of the ways in which practices, purposes, and participants may interact in a science classroom. "The teachers we work with don't focus on

(continued...)

(...continued)

whether something, in general, is a good or bad practice. Instead, they focus on what is being accomplished by a particular teacher and group of students at a particular time in a particular setting. They then use that as the foundation for further conversation and pedagogical action or inquiry."

Rosebery contributes another consideration of paraphrasing for English-language learners. "While it may be a good strategy, many times teachers are taught to adopt practices without thinking about the circumstances under which these practices are best used. This incident, to us, was bigger and more complex than simply questioning the use of paraphrasing in the classroom. We saw these teachers beginning to question the appropriateness and the purpose of particular instructional moves—certainly not to the point of paralysis, but examining the effects of a practice in a particular situation."

DEVELOPING RESPECT FOR LEARNING

As Rosebery and Warren expand their work to 13 school districts nationally, they are working to document the effects of their professional development upon classroom practice. "We don't expect teachers to revamp their entire science programs immediately," Rosebery says. "Instead, we encourage them to pick a single unit of study and think about how they might revise it. We encourage them to audiotape and videotape in their classrooms as they try these pedagogical experiments and to use these tapes as a focus for discussion with colleagues."

Warren adds, "As part of our classroom research, we often interview students in a strategic way during the time they're engaging in a particular inquiry. We meet with the classroom teacher to look at the videotapes. The data are examined from the point of view of student learning and achievement."

In their collaborations with teachers, Rosebery and Warren have been surprised over the years in at least two ways. "We've seen how much we love to learn science with the teachers," Rosebery says. "By doing science ourselves, we're able as researchers to better enter the world we study."

Warren discusses another surprise. "We've often been told that teachers won't do such and such—whether it's reading a book or videotaping their classrooms. While what we ask is sometimes more than teachers realistically can take on, it's never really been a problem for us. In fact, in our experience we find that teachers are thirsting for this kind of professional engagement and intellectual inquiry."

This has been an important lesson to both researchers, she continues. "Through our years of doing this work, we've learned that good teaching depends on teachers being learners themselves, both inside and outside the classroom. To the extent that we as researchers respond to that, the more effective our work will be and the more effective their work will be."

Rosebery points to the benefit of working with other researchers within NCISLA. "We see real threads of connection among the work that Tom Carpenter and Megan Loef Franke do, the work that Rich Lehrer and Leona Schauble do, and our own work. Our approaches are somewhat different, but there are many fundamental threads that unite us."

WISCONSIN CENTER FOR EDUCATION RESEARCH
School of Education • University of Wisconsin–Madison
1025 W. Johnson Street • Madison, WI 53706
Phone: 608-263-3605 • Fax: 608-263-3406
E–mail: ncisla@mail.soemadison.wisc.edu • Web Site: http://www.wcer.wisc.edu/ncisla

NEWSLETTER INFORMATION

Volume 2, Number 2 • Fall 1998

Dissemination Coordinator
Susan Anderson

Newsletter Production
Kristen Roderick

(...continued from page 12)

Ann Rosebery and Beth Warren engage teachers who teach in culturally and linguistically diverse classrooms in the Boston area in an examination of their own learning of science, their teaching, and student thinking as interrelated sense-making. In their approach to professional development, teachers routinely come together to explore their questions about scientific ideas and phenomena and to bring into contact their own, their students', and scientists' ways of making sense of the world as the basis for elaborating their classroom practice. In this model, professional development interweaves teachers' inquiry in science with inquiry into diverse children's ways of talking and knowing, in an ongoing reflexive fashion. This interweaving forms the ground for innovation in teaching practices in diverse classrooms.

PROFESSIONAL-DEVELOPMENT THEMES

Four themes characterize the professional-development programs being studied by NCISLA researchers: (a) helping teachers understand the development of student thinking in mathematics and science, (b) enriching teachers' knowledge of mathematics and science content, (c) helping teachers engage in practical inquiry, and (d) assisting teachers to form communities of practice.

Knowledge of student thinking. Foregrounding student thinking is a major theme that characterizes professional development in Center projects. All of the projects focus on developing understanding of student thinking in specific content domains.

Teacher knowledge of mathematics and science content. Because learning trajectories are situated in specific content, constructing them requires a substantial understanding of the content domain, and, therefore, learning of mathematical and scientific content is an essential element of professional development. Different projects take different stances in dealing with content knowledge. Rosebery and Warren specifically focus on knowledge of ideas and practices of knowing, engaging teachers in explorations of mathematics or science to support their own understanding of these topics. Franke, Lehrer, and Schauble embed content learning in the study of children's mathematical thinking, and Lehrer and Schauble also feature it prominently in activities related to the design of instructional practices.

Practical inquiry. A major factor in teachers' professional development is their engagement in inquiry. Lehrer and Schauble focus directly on engaging their teachers in inquiry by providing opportunity for them to author classroom tasks that they share with other teachers. In Franke's and Warren and Rosebery's studies, teachers engage in practical inquiry as they struggle to make sense out of their students' mathematical and scientific thinking and discourse.

Communities of practice. Professional development cannot be captured only by looking at individual teachers' knowledge, beliefs, and practices. Teachers' professional development takes place in a community of practice, and it is necessary to understand those communities and teachers' roles in them. As a consequence, the projects are studying both individual teachers and the multiple communities of practice in which they participate. Particularly critical for Center research are the communities of researchers and teachers collaborating to design innovative instructional practices.

PRINCIPLED PRACTICE IN MATHEMATICS AND SCIENCE EDUCATION *is published by the National Center for Improving Student Learning and Achievement in Mathematics and Science, Wisconsin Center for Education Research, School of Education, University of Wisconsin–Madison.*

This publication and the research reported herein are supported under the Educational Research and Development Centers Program, PR/Award Number (R305A60007), as administered by the Office of Educational Research and Improvement, U.S. Department of Education. The opinions expressed herein are those of the authors and do not necessarily reflect the views of the supporting agencies.

Permission to copy is not necessary. • This publication is free upon request.

Address inquiries to the Center, Attention: Pat Boustany, or to our E–mail address.

Comments From . . . Thomas P. Carpenter, Acting Director

Professional Development: NCISLA Projects & Themes

All of the school-based research in NCISLA is conducted in partnership with participating teachers. As such, all of our research is engaged at some level in professional development. Three projects specifically studying professional development have been discussed in this newsletter, and another was the focus of the spring 1998 newsletter.

Megan Loef Franke is extending earlier work on Cognitively Guided Instruction to explore how teachers in an inner-city Los Angeles school construct knowledge about student thinking by engaging in practices that cause them to examine student thinking related to specific problems. Teachers meet in work groups to analyze how students in their classes solve problems, with the goal of constructing a model of student thinking that explains the teachers' observations. Problems are carefully selected to provide a window on critical features of children's mathematical thinking and the ways their thinking develops.

Richard Lehrer and Leona Schauble (see the spring 1998 newsletter) are concurrently studying student learning, teaching practices that support students' learning, and professional development that supports these teaching practices. The unifying theme for their work involves the generation, application, and revision of scientific and mathematical models of the world. Teachers work individually or in teams to construct model-eliciting tasks and document major transitions in students' thinking as they engage in cycles of modeling. The documentation of student thinking represents a critical feature of this process.

• • •

(continued on page 11...)

NATIONAL CENTER FOR IMPROVING STUDENT LEARNING
AND ACHIEVEMENT IN MATHEMATICS AND SCIENCE
Wisconsin Center for Education Research
School of Education, University of Wisconsin–Madison
1025 West Johnson Street, Madison, WI 53706

Nonprofit Organization
U.S. POSTAGE
PAID
Madison, Wisconsin
Permit No. 658