Hands On!

Winter 2007/2008 Volume 30, Number 2

A magazine for mathematics and science educators

TERC

Inside... Do Plants Grow Everyday? – **7** • Learning Science Online – **11**
A Data Coach's Guide to Improving Learning for All Students – **16**

SOWING THE SEED OF DIVERSITY

A Call to Diversify Physics Through Small Social Interactions

By Maria Ong

In the 21st century, promoting the interest of all students in physics as well as other STEM (science, technology, engineering, and mathematics) disciplines should be a central concern to U.S. educators, scientists, and citizens. As never before, we must focus on the recruitment and retention of females and students of color.

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Teaching Science to English Language Learners:

Building on Students' Strengths

Ann S. Rosebery and Beth Warren, Editors

Can a student's cultural resources support learning in science?

Or is concentrating on the specialized vocabulary of science the best way to help English language learners learn science? This book addresses these and other pressing questions you face when working with students whose linguistic and cultural backgrounds, as well as their languages, are different from your own.

Teaching Science to English Language Learners combines research findings with classroom vignettes and teacher perspectives. The authors strive to support your efforts to see diversity as a resource—rather than as an obstacle—in the science classroom.

TOPICS INCLUDE:

- Building on what students know and recognizing students' strengths
- Teaching vocabulary for learning
- Supporting the development of academic language
- Challenges associated with learning a second language
- Types of programs for teaching English language learners
- Using students' cultural resources

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For more than 40 years, TERC has carried out its mission to improve science and math education for all students by looking to the future, anticipating emerging needs in education while staying grounded in the realities of the current classroom.

TERC remains a leader in researching the use of technology in education. One recent line of research examines science learning in the online medium (page 11).

The demographics of the U.S. classroom are clearly changing. The Chèche Konnen Center has been anticipating these changes for more than twenty years through research on supporting the science learning of children from communities historically underrepresented in the sciences (page 7).

The cover article addresses the need for greater diversity among science professionals. Research points to social barriers for women of color, indicating unique solutions not part of the typical work pipeline conversation.

Meanwhile, the Using Data project is addressing the immediate needs of districts where accountability is the driving force, by going beyond rhetoric and preconceptions to create measurable, lasting change (page 16).

Zoe Keller,
Editor

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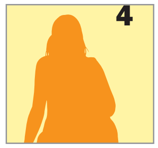

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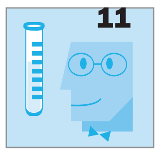

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SOWING THE SEED OF DIVERSITY

A Call to Diversify Physics Through Small Social Interactions

By Maria Ong

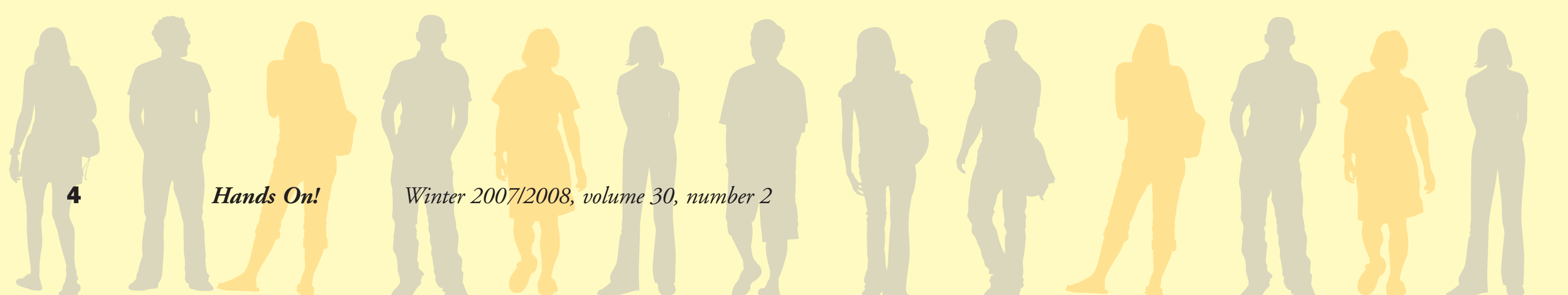
The United States faces a crisis caused by a gap between an increasing need for scientists and engineers and the decline in the number of STEM majors. The growing void points to the neglect of our own young people as potential resources to fill critical positions in STEM. In recognition of the "quiet storm," as Shirley Ann Jackson termed the impending crisis, agencies such as the National Science Foundation, the American Society of Engineering Education, and the American Physical Society have called for the United States to cultivate its domestic resources that explicitly include women and racial/ethnic minorities.

However, before we can fix the problem, we need to better understand the cause. Through sociological research I have conducted over the past decade, I have sought to address effective ways to recruit and retain young people, especially women and racial and ethnic minorities, in physics. A number of studies amply document how physics departments and professional laboratories operate as cultures that are often unfriendly to women and minorities. My research focuses on contexts of success: the day-to-day work and academic environments as experienced by 28 female and minority students—of which ten are women of color—who would eventually earn bachelor's degrees and pursue graduate school and/or careers in physics or a physics-related field. Through annual interviews and ethnographic observations conducted over a 10-year period, I have endeavored to identify the challenges encountered by these students, as well as the strategies that fostered their ability to persevere.

One of the more important, and perhaps surprising, findings is that sometimes even subtle interactions can have a significant impact. For example, an undergraduate physics major's social experiences with peers and faculty can strongly influence his or her decision to abandon or pursue a physics degree. In my research, I have found that students' experiences of alienation and being disrespected by peers or faculty members often outrank other contributing factors, including grades. While most physics students might typically react to such experiences the same way, women and racial minorities are particularly vulnerable to messages that define them as outsiders.

To understand the perceptions held by women and minorities, consider the following remarks that were expressed by some of the students who participated in my research study:

A whole class of us will be working, like, two hours before some homework is due, and we'll have different answers. And everyone will make an argument as to why their answer's right. You know, for the benefit of everyone. And so we all help each other, and everyone's helping everyone. But there's so many [male] students who are so willing to help me, but unwilling to hear me when I say something. — CHICANA STUDENT



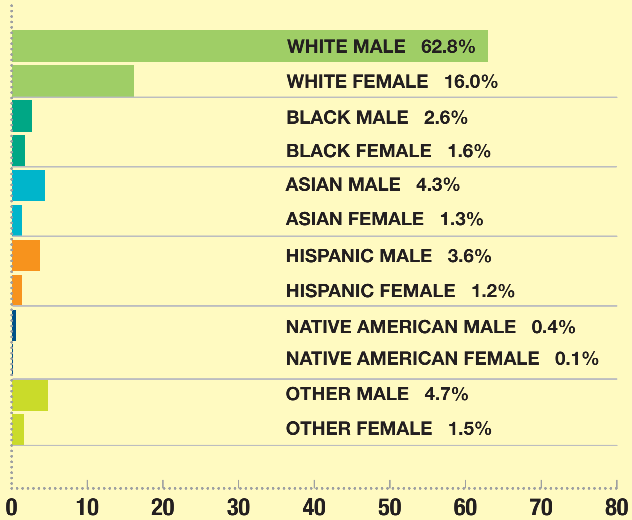
If we asked [the professor] a question, he'd talk to us like we were kindergartners.... Whenever we asked him for something, it would take three hours to explain it to us, and we wouldn't have that time. When you have only four or five days to an experiment, you can't miss a whole afternoon on one minor thing.

— LATINA STUDENT

My [male] partner and I had this question on some lab we were doing and we were asking [the professor] questions, and the thing is, I would ask a question. He would say about one sentence to me, and then the rest of his conversation was directed at Dave, my partner. And I have no idea why he did that. Because [the professor's] a great guy. You know, I wouldn't think that he has anything against women. I'm sure he had no idea he was doing it.

— FILIPINA–AMERICAN RECENT GRADUATE

Bachelor's Degrees in Physics Awarded to U.S. Citizens and Permanent Residents (2004)



National Science Foundation, Division of Science Resources Statistics, *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2007*, NSF 07-315 (Arlington, VA; February 2007)

When members of a group that are marked by a particular stereotype, and risk the possibility of conforming to or being judged in terms of that stereotype (e.g., "females aren't good at math"; "African Americans lack intellectual aptitude"), they respond—in an effort to reinforce their group identity—by "disidentifying" with a domain (e.g., math or science).

Psychologist and author Claude Steele called such domains "stereotype threats." Steele argued that this phenomenon can be especially harmful to "the academic vanguard," that is, high-achieving students of a particular group who choose to be in a domain for which their group is negatively stereotyped. These students can be successful in school and still be at risk for abandoning the discipline or dropping out of school entirely.

Even when women and minorities display greater skill and competency than their white-male counterparts, they may continue to experience stereotype threat and may eventually lose confidence in their abilities.

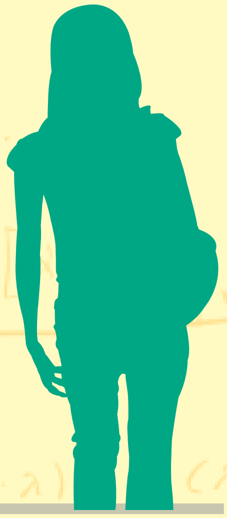
I just remember at times, taking exams [in upper division] where I was the only minority woman … and just being so convinced that everyone just looks smarter than me. And I'll sit there and I'll think, 'No, it's not true.' But [it's hard] to really change the way you feel.

— CHICANA STUDENT

An important and rather controversial implication of Steele's work is that remedial programs for women and minority students, though well-intentioned, serve to reinforce the very stereotypes that would cause these particular students to underachieve in the first place. Perhaps a more effective approach with students who already identify with academic achievement would be to reduce stereotype threat by establishing learning environments where the bar for achievement is high and no student's ability is questioned.

For students who disidentify with a particular domain, instructors can foster more positive academic identities through safe learning environments where there is "little cost of failure," thereby fostering students' sense of self-efficacy and competence. One student comment from my study illustrates the impact of such an environment:

My grade in physics is what kept me in the University. And I would not have been able to get that grade had I not gone through the program, for sure. I have had more support than probably any one person deserves. I mean, I've had a really great support team. The instructors, program directors, teaching assistants, all of them, have always been really rooting for me. And that really means a lot. Probably the single most important thing that you need to get through this place is someone to say, 'We believe in you.' It really makes you rise to the occasion.
– AFRICAN-AMERICAN STUDENT



Fortunately, models of positive learning environments for minority students already exist in physics and other STEM programs. Among the most well known, perhaps, are the Meyerhoff Scholarship Program at the University of Maryland at Baltimore County (www.umbc.edu/meyerhoff) and the "workshop" model founded by P. Uri Treisman, which began in the mathematics department at the University of California at Berkeley, and has since been implemented in STEM disciplines all around the country. A "workshop" type of program—which had the characteristic collaborative group work and deep-level problem solving—was implemented in the lower-division physics courses where I conducted a large part of my research. While it welcomed all students, it served primarily minority students. The physics department also sponsored the Women in Physics Group, which served as a resource for professional development. In addition to hosting a website that featured information on the graduate school application process and national conferences, the group sponsored monthly events that brought together undergraduate and graduate students, as well as faculty. The group's monthly meetings often revolved around the concerns of aspiring women scientists—ranging from discussions on how to balance family and a career in physics to lab simulations that help undergraduates gain experience using the tools and equipment common in experimental physics.

Indeed, subtle messages that convey exclusion undermine efforts to recruit and retain women and minorities. Yet, small, incremental attempts at social inclusion can have a significant impact on increasing the number of minorities in physics. Toward that end, more physics departments should sponsor support programs and social events that welcome undergraduates. Such efforts require money, space, and time, but the more undergraduates are engaged in their education and departmental culture, the higher the high return on investment.

Due to the still prevalent assumption that gender and racial equity and the attainment of excellence are incompatible goals, STEM fields, in general, and physics, in particular, continue to be among the most segregated and conservative of domains. Last year, I founded Project SEED (Science and Engineering Equity and Diversity) as an initiative of The Civil Rights Project at the University of California, Los Angeles, to highlight the many benefits of gender and racial diversity; call upon diversification and equity in STEM as a social justice issue as well as a national security issue; and challenge the prevailing exclusionary definitions of "best and brightest" and "excellence" in order to make it more inclusive and compatible with the demands of a democratic society.

In the end, diversity benefits not only women and minorities, but all individuals and institutions by making them more creative and competitive.

For more information, see: http://www.civilrightsproject.ucla.edu/convenings/seed/synopsis.php

The research was funded in part by the Harvard Graduate School of Education, the American Educational Research Association, and the University of California at Berkeley.

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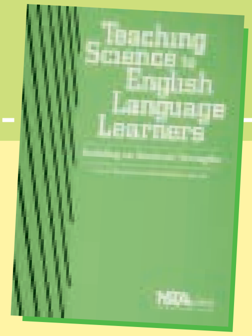
Do Plants Grow Everyday?

by Ann S. Rosebery and Cynthia Ballenger



The following excerpt is from a new NSTA Press publication, "Teaching Science to English Language Learners," edited by Ann S. Rosebery and Beth Warren. The article is taken from the chapter, *Creating a Foundation Through Student Conversation*.

Can students learn science before they are proficient in English? Do students need to master basic skills before they can engage in scientific inquiry? Is concentrating on the specialized vocabulary of science the best way to help English-language learners learn science? Can a student's cultural background interfere with or support learning in science?

The full volume addresses these and other questions frequently asked by educators teaching science to English-language learners. It offers a variety of voices in response. Through education-related research, classroom case studies, and the perspectives of classroom teachers, the volume offers valuable information for teachers who wish to reflect on, experiment with, and adapt their instructional practice. Its aim is to support educators in their efforts to see linguistic and cultural diversity as a resource—rather than as an obstacle—in the science classroom.

The volume was developed by the staff of the Chèche Konnen Center at TERC, dedicated to improving science learning for children from communities underrepresented in the sciences. **http://chechekonnen.terc.edu**

Science Talks

In this essay, we discuss a pedagogical practice called *science talks*. Science talks are conversations in which students use their diverse language practices and life experience to understand scientific phenomena.

Most teachers organize science talks around students' questions, using them in conjunction with their existing science programs, by returning to questions that students have asked during the week. The teacher's role during science talks is to listen to and reflect on her students' ideas in order to create a foundation for designing lessons that are both responsive to students' thinking and responsible to the curriculum.

Science talk simultaneously builds students' conceptual understanding and sustains their passion for science. As students participate, they learn how to present a point of view with clarity, make evidence-based arguments, answer challenging questions persuasively, revise their thinking in the face of counter evidence, clarify their own thinking by talking to others, and raise new questions.

Because science talks are a time for students to think out loud together, every student can have a voice in the curriculum. Even students who struggle with reading, writing, mathematics, or English have ideas and questions about the world. Many teachers are surprised to see these students emerge as intellectual leaders during science talks.

This case study focuses on an event that took place in a third grade classroom in a two-way bilingual program in Cambridge, Massachusetts. For a more in-depth discussion of this science talk, see Ballenger, 2004.[1] Half the students speak Spanish as a first language and are learning English; the other half speak English as a first language and are learning Spanish. The students are studying plant growth and development using *Plant Growth and Development* by the National Science

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Resources Center[2]. They have been collecting and recording data on plant growth for several weeks. During the investigation, their teacher, Ms. Pertuz, listed their questions on chart paper. On this day, Ms. Pertuz has decided to try a new kind of discussion called science talks for the first time. The class is considering the following question posed by one student: "Do plants grow everyday?"

While almost all students in the class participate in this science talk, we focus on two students, Elena and Serena. Elena is from a working class family; her parents have little formal schooling. Her mother is from Mexico and the family speaks both Spanish and English at home. She is repeating third grade and Ms. Pertuz is concerned about her progress. Elena rarely speaks during academic lessons and until now has been almost silent in science.

By contrast, Serena is seen as a strong student. While her parents, too, are immigrants to the United States, they are from highly educated families. Both her father and mother hold advanced academic degrees. Serena is fluent in both Spanish and English, including academic Spanish and English, and participates actively in school.

A classmate, Desiree, begins the science talk by reading her question aloud, "Do plants grow everyday?" Serena responds by claiming that plants do grow everyday but "our eyes can't see it." She explains that the measurement tools they have been using may not be able to detect the small increments that the plants grow each day ("Our rulers can't be perfect."). That notwithstanding, she invokes the charts and graphs the children have been keeping as evidence that plants grow everyday. For Serena, the charts and graphs are proof of daily growth.

Juana, a student who rarely participates, then asks, "How come we can't see them grow? And how come we can't see us grow?" In contrast to Serena's focus on measurements and graphs, Juana focuses on the plant. She wants to see it grow, and see herself grow. Then Elena says, "I don't think we could see them grow, but I think they could *feel* theirselves grow. Sometimes we can feel ourselves grow because my feet grow so fast cuz this little crinkly thing is always bothering my feet. That means it's starting to grow. It's starting to stretch out."

Prompted by Juana, Elena is thinking about the moment-to-moment process of growth. How would growth *feel* to a plant? As she describes the crinkly thing in her feet, she wriggles her nose, and she makes her voice high and throaty. It is as if she is trying to re-experience for herself, and dramatize for others, the crinkly feeling of growth by re-creating it in her imagination, and physically, in her intonation and body movements. Unlike Serena who was observing the plant from the outside, Elena is thinking and talking about growth from a perspective inside her own body, aligning herself with the plant. In her imagination, she is with the plant, not on the growth chart as Serena is.

Recognizing Student Contributions

Many teachers would be impressed by Serena's use of graphs and charts to find and justify an answer to Desiree's question. Serena seeks to represent the plant's growth through objective measurement, from a perspective outside the plant. Her approach highlights the value of recorded measurements and data. Learning to make, read, interpret, and use charts and graphs is key to acquiring a scientific perspective. Serena's response can rightly be heard as scientific, perhaps even as "the answer." In another situation, it might end the discussion. There is much about growth that this perspective leaves untouched, however.

Elena's approach, on the other hand, invites her classmates and the teacher to wonder about growth as it takes place in real time. By imagining herself inside the plant and trying to feel what her own growth is like, Elena positions them all to wonder what exactly is going on as something grows. She invites them to think with her about growth as three- rather than two-dimensional, as something that results in filling socks and shoes as well as in getting taller. She also prompts them to think about *when* growth happens and what its pattern might be. Does it happen in constant little increments or is it more punctuated, less predictable?

Many renowned scientists have "imagined" the world at other levels as Elena is doing, especially when working at the edges of their understanding. The Nobel Prize winning biologist Barbara McClintock said the following about her work with the chromosomes of *Neurospora*, a red bread mold: "When I was really working with them I wasn't outside, I was down there. I was part of the system. I was right down there with them and everything got big. I even was able to see the internal parts of the chromosomes—actually everything was there. It surprised me because I actually felt as if I was right down there and these were my friends."[3] Elena's embodied, imagined way of thinking about plant growth echoes McClintock's experience and words, experience that was crucial to the trail-blazing science McClintock conducted.

By imagining growth in a sensory way, Elena makes accessible otherwise unexamined scientific aspects of the plant's growth process, e.g., what might be happening inside the plant as it grows. It changes the relationship that she and her classmates take toward what they know. Her imaginative, embodied approach makes it possible for other children to question and examine knowledge that they might otherwise ignore. Not only does their discussion and probing become more specific and grounded but more children—children who are typically quiet in science (like Elena and Juana)—participate. From here, the children go on to consider and imagine other aspects of a plant's life from a biological perspective. They consider, for example, how the sun gets inside the leaves. Elena's approach proves to be an important perspective with which the other children, including Serena, can engage. Similar to practicing scientists, these children, led by Elena,

Chèche Konnen Center

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use their imagination as a powerful scientific tool to enter a natural phenomenon in order to better understand it.

Because Ms. Pertuz wants to hear the students' ideas—particularly of students like Elena and Juana, who to this point have not participated in science—she allows the conversation to continue past what might otherwise have been seen as "the answer" provided by Serena. Because Ms. Pertuz is prepared to listen carefully for connections between her own knowledge of plant growth and the children's ideas, she recognizes Elena's contribution to this discussion, which she otherwise might have dismissed. Ms. Pertuz realizes that the contributions of *both* Elena and Serena play important roles in deepening the class's thinking.

What the Teacher Learned

Ms. Pertuz, like her students, benefits from the science talk. First, she achieves a new perspective on several of her students. To her surprise, she hears from many quiet students and discovers that despite their silence, their minds are going a mile a minute, and they have much to contribute to the discussion. She also sees students like Elena and Juana assume roles of intellectual leadership, something she had not seen before. As a result, Ms. Pertuz sees students like Serena, whom she thinks of as academically strong, benefit from ideas and perspectives articulated by students whose academic skills are of concern to her.

Secondly, this science talk reinvigorates Ms. Pertuz's own interest in the science of plant growth. The children's ideas and perspectives stimulate her to think about growth in new ways and to wonder what moment-to-moment growth in a plant might indeed look like. She is left with many exciting, potential directions in which to take the children's inquiry. Should they explore growth as three-dimensional? If they were to do this, how might they measure it in their plants? And in themselves? What are other ways of making growth visible and of representing it? Of course, Ms. Pertuz did not *see* all of this during the science talk. That is not possible. As part of adopting a new role for herself, she took notes as the children spoke. She also had the session videotaped. Her notes and the video record enabled Ms. Pertuz to sit down with colleagues at a later time and reflect on what the children had said and done, deepening her sense of their thinking and the possibilities for pursuing their ideas and questions.

Getting Started with Science Talks

1. Engage students in a common activity with a scientific phenomenon.
2. Initiate an open-ended discussion about the event with your students.
3. Listen carefully to what your students say as they share their thoughts.
4. Encourage your students to talk with one another, allowing them to use a range of language styles to communicate their ideas.
5. Act as a facilitator, rather than as a teacher, of the conversation.
6. Allow the conversation to develop and unfold with as little intervention on your part as possible.
7. Assume that the students understand one another, even if you do not yet understand what is being said.
8. Reflect on your students' ideas after the science talk has concluded. Consider meeting with other teachers to discuss the science talk.

Conclusion

In *Talking Their Way into Science*, Karen Gallas[4] writes, "Children come to school fully prepared to engage in scientific activity, and the school, not recognizing the real nature of scientific thinking and discovery, directs its efforts toward training those natural abilities out of the children." As our case study demonstrates, this does not have to be the case. All children, regardless of their first language or educational background, come to school with rich experiences of the world and ways of accounting for them that can be used as resources in learning science. A major challenge facing teachers who teach children from backgrounds different than their own is to learn how to recognize the instructional potential of such resources.

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LEARNING SCIENCE ONLINE:

A Descriptive Study of Online Science Courses for Teachers

By Jodi Asbell-Clarke and Elizabeth Rowe

Online professional development is a rapidly growing phenomenon for science teachers, yet there is a startling dearth of studies or even descriptive information about online learning. To address this research gap, TERC recently published the first multi-institutional study of online science courses for teachers, Learning Science Online (LSO), funded by the National Science Foundation.

Using a sample of 40 online science courses for teachers offered during the 2004-2005 academic year, the LSO study asks: **Who are the students in these courses? Who are the instructors? What does science teaching and learning look like in these courses?** The result is the first ever aggregate study of online science courses from a wide variety of educational programs.

An early release of the study's findings in November 2006 was accompanied by a two-day conference with LSO program representatives and advisors, including LSO staff, instructors, and curriculum developers from the online programs studied, other science educators, online education researchers, gender studies researchers, and quantitative research methodologists. The rich discussion served to deepen understanding of the study's results; encourage reflection on how the findings could impact participants' own teaching and learning practices; and identify fertile ground for future study.

This article presents a brief overview of the state of online learning for science teachers according to LSO, as well as key insights from a panel of researchers and online course developers.

LSO Study Background & Participants

LSO is a mixed-method longitudinal study of online science courses for K-12 teachers that were offered during the 2004-2005 academic year.

Courses that met the criteria for the study (a) focused on science content (as opposed to pedagogy), (b) offered at least one graduate credit, and (c) had the majority of interactions online. LSO collected data from course instructors, students, and program coordinators at each course's home institution. Pre- and post-course questionnaires from instructors and students are the primary data sources, along with program coordinator interviews and instructor reports of student performance.

All six program coordinators, 40 of the 47 instructors (85 percent), and 296 of the 800 students (40 percent) provided complete information and were included in these analyses. Courses targeting high school science teachers and students who performed well in the courses are over-represented in this study—two limitations central to interpreting the findings.

Who Is Learning?

Who is taking part in online science learning? Is there broad and equitable participation in this new phenomenon? Do the students reflect the broader teaching population, or are these courses reaching an audience of teachers different from the audience reached by other forms of professional development?

Online science courses enroll more females, more early career teachers, and more teachers from small towns and rural communities.

LSO found that online courses reach a different audience than other forms of professional development. When compared with the general field of U.S. science teachers, online science courses enroll more females, more early career teachers, and more teachers from small towns and rural communities. Panelists from the 2006 LSO conference speculated on possible reasons for some of these findings and suggested further action and study.

GENDER: Two-thirds of the students in LSO courses were women. This is notable because the overall number of women in the teaching force decreases dramatically between elementary school and high school, particularly in science. The LSO study had a larger percentage of courses geared for high school teachers, suggesting the overrepresentation of women would have been even higher had more courses for elementary school teachers been included as well. The high proportion of females in these courses, and their consistent reporting of active participation in online discussions, may go against popular beliefs that women are intimidated by science courses or are more technology-phobic.

Panelists noted that online education may be reaching out to and connecting with women in new ways that should be fostered. The higher than anticipated percentage of women in these online courses may indicate that online learning opportunities are more suited to women's lifestyle needs; more women may be fitting their education in among their regular work and home duties. The emphasis on communication in online environments may also be an attractive feature for female learners. Research is needed to understand how positive practices in this area may be transferable to other learning environments.

RACE: Minority teachers make up about 40 percent of the U.S. teaching force, but constitute only 10 percent of the student population in online science courses. The most probable explanation for this is the underrepresentation of minorities teaching in science, particularly in rural and small-town locations, which are overrepresented in this sample. The 10 percent number roughly reflects the overall percentage of minority teachers in high school science nationwide, which is 10-15 percent, depending on the specific field (CCSSO, 2005).

Minority representation was of concern to all panelists. Several of the program representatives explained that recruitment priorities are first focusing on ensuring that courses are viable before ensuring the diversity of the students. It was also noted that minority teachers perhaps might not be reached by the current advertising and recruiting methods. Panelists suggested that in schools where other forms of professional development take precedence, minority teachers might not attend conferences or read publications where these online programs are advertised. Some programs have had more success recruiting minority teachers by networking within school districts and connecting with other learning institutions (for example, creating a partnership between an urban museum and local public schools).

TEACHING EXPERIENCE: Students in LSO courses were more likely to have less than ten years of teaching experience relative to their counterparts in the general teaching population. The majority of students in these courses were seeking significant professional development, most often through a master's degree, which likely reflects their being in the early stages of their careers. It is also possible that younger teachers represent the wave of native technology users as opposed to older and more experienced teachers who are more typically new immigrants to technology.

Panelists suggested that institutions should take advantage of the new generation of online learners to utilize this medium for rich content delivery. The need for professional development often comes just at the busiest time of teachers' careers and often when they are also juggling family responsibilities at home. Online courses make it possible for young teachers to fit in professional development when they otherwise would be unable to, especially if it demanded a long commute.

GEOGRAPHY: Although most students in the study taught in suburban and urban communities, they were more likely to be teaching in rural communities and small towns than teachers in the general teaching population. Teachers in rural areas and small towns may not have access to as many face-to-face professional development opportunities as those working in more populated areas. Online professional development seems tailored for teachers working in more remote locations. While Internet access is still lower for people in rural areas, the gap between rural and urban Internet usage is narrowing. Active recruitment to rural school districts might prove fruitful for programs looking for more students.

Who Is Teaching?

Online courses also offer fresh opportunities for faculty and may foster a new style of instructor who differs from traditional science or science education faculty. Do instructors in online science courses for teachers represent the typical science professor, or are these courses tapping a different group of potential instructors?

The LSO study showed that in online science education programs run by universities, instructors of online science courses resemble the broader science professoriate—predominantly male, mid-fifties, a Ph.D. in science, little K-12 teaching experience. There is one notable difference between the online instructors in university programs and typical university science professors: no instructor of an online course was actively pursuing tenure. Instead, instructors were either already tenured faculty or were non-regular faculty (part-time, adjunct, lecturer). This seems to suggest that tenure-track faculty do not see teaching online science courses for teachers as an activity valued by their institution.

However, in courses offered by non-profit organizations, instructors of online science courses for teachers did not resemble the broader science professoriate; they were predominantly female, were less likely to have earned a Ph.D. in science, and had considerable K-12 teaching experience. All of them had experience teaching online and had taken a formal facilitation course.

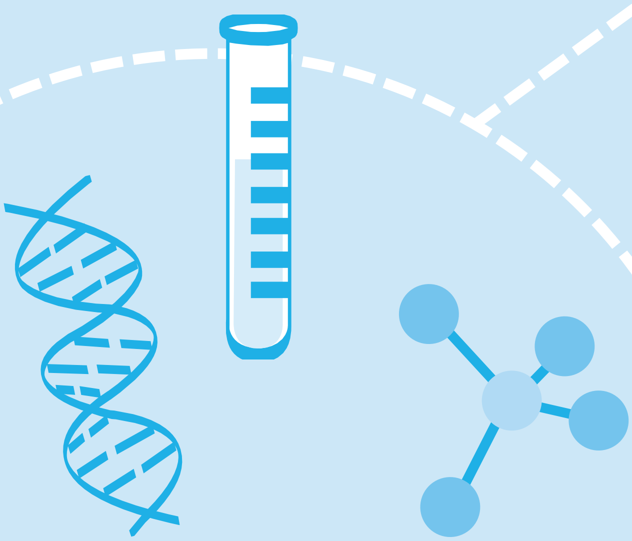
Panelists agreed that the ideal online instructor has a strong grounding in science content; is a natural communicator of ideas; and is comfortable enough with technology and the nuances of online communication so that the new medium is not a problem. Some programs find that instructors who use a rich, layered approach that synthesizes science content expertise, classroom experience, and technology skills hit upon a powerful "best practice" combination and in some cases, it takes a team of people to bring the best of these strengths together.

What Does Teaching and Learning Look Like Online?

The online environment offers new tools and different social structures in which learning can take place. Many inquiry-based models of science professional development for teachers advocated by national standards and educational research involve collaboration and other social ways of learning, as well as authentic scientific contexts and hands-on investigation. Do online courses for science teachers take advantage of the new learning environment to promote inquiry-based science learning?

Overall the study revealed many indicators of social and inquiry-based learning in these courses. It appears that in the online context, collaborative and discussion-oriented learning models have replaced a teacher-based lecture style science course. It also appears, however, that some valuable elements of typical face-to-face courses, such as hands-on activities and fieldwork, have not yet made it into many online science courses for teachers, which is of concern.

HANDS-ON ACTIVITIES: Courses varied in their use of hands-on activities, but these activities were generally rare. There was also very little fieldwork or laboratory experience associated with the LSO courses. Panelists suggested that it is difficult to design authentic field investigations that are suitable for people at any geographic location. They also recommended that online courses seek out supplementary enrichment sources, such as partnerships with laboratories for teacher research experiences.



Surprisingly, computer simulations are rarely used in the LSO online courses. Panelists explained that the development costs to create good simulations are a barrier for most programs, and the ones available on the Web are not necessarily suited to their particular needs or audiences. In the recent past, and still in some places today, bandwidth has been a consideration.

SOCIAL AND INVESTIGATIVE LEARNING: Students reported high frequencies of articulating and reflecting on their own ideas and the ideas of others; reading and responding to discussion postings from their instructor and peers; raising questions with other students about scientific ideas; as well as analyzing data and providing evidence to support ideas. These are all indicators of a very social learning environment, and possibly what could be called a community of scientific inquiry. Panelists suggested that further examination of the quality and nature of the science being discussed in these online communities may reveal interesting information about the social construction of knowledge.

Panelists also suggested that the online environment challenges people to think more deeply in an investigative way. They noted that material is covered more slowly online, but students seem to "get it" just as well, or better, when there is a lot of time for reflection and digestion of material online. They noted that online education in some ways is more public, and thus social, than face-to-face classes. Everyone typically sees everyone else's posted research and assignments and there is a visible "paper trail" documenting students' ideas as they progress.

ASSESSMENT AND ACCESSIBILITY: Online discussion contributes from 0 to 50 percent of the grade in LSO courses. Most instructors use either frequency of participation or some informal evaluation of the general discussion in order to assess discussion. Panelists agreed that there are no clear methodologies used to grade online discussion, but that the discussion does have powerful potential to assess student learning. More research and development is called for in this area.

Is online learning serving its entire potential audience, or are there barriers that exclude some learners even in this booming new mode of education?

Students in LSO courses reported frequent and helpful feedback from instructors, but less so from peers. Peer evaluation is not used frequently as a means of assessment, which is interesting given the social nature of learning that is apparent in these courses.

Questions for Further Study

As panelists discussed the LSO findings on the whole, they were left with several important questions for the field.

Is online learning serving its entire potential audience, or are there barriers that exclude some learners even in this booming new mode of education?

As programs seek to recruit new and diverse audiences, they must keep in mind that not all learners will be attracted to or served by new technologies for learning. A close eye should remain on how to use the affordances of online environments to open doors for learners, particularly to those typically marginalized in science education.

Are online courses utilizing the technology to its fullest potential, or are there untapped ways of learning that may be possible with the new tools available?

The panel was surprised at the dearth of computer simulations and hands-on activities in the LSO courses. The former seems like a natural fit with online learning, as web-based computer interactives are only a click away when working in an online environment and can be a highly useful way to present sophisticated phenomena and scientific models. Hands-on activities are often the bread and butter of face-to-face science teacher professional development workshops, and their absence from online courses is a bit disconcerting. Techniques should be sought and promoted to integrate hands-on work with the online discussion that does take place in these courses.

The online professional development field is still young, but holds great potential for embracing inquiry-based instructional methodologies as it becomes a greater and greater force in the educational arena.

The complete LSO study, the executive summary, and the conference report are available online at: http://www.terc.edu/work/899.html

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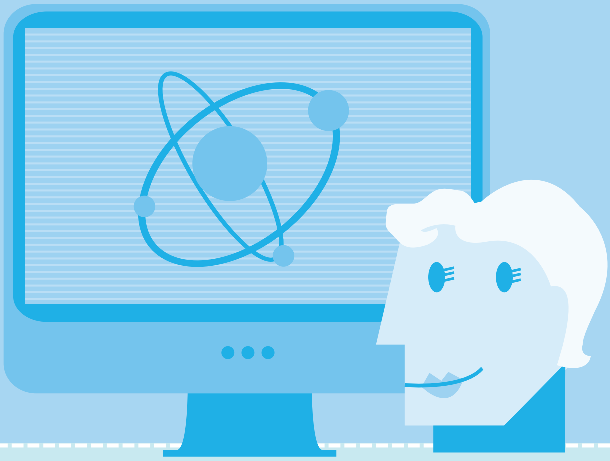
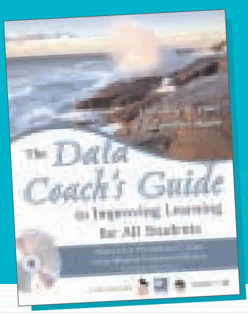


Are online courses utilizing the technology to its fullest potential, or are there untapped ways of learning that may be possible with the new tools available?

feature

A DATA COACH'S GUIDE *to* IMPROVING LEARNING FOR ALL STUDENTS

Unleashing the Power of Collaborative Inquiry



By Nancy Love, Katherine E. Stiles, Susan E. Mundry, and Kathryn DiRanna

The following excerpt comes from the introduction to A Data Coach's Guide, a new publication from Corwin Press.

Despite endless pessimistic messages about the state of public education, as staff of the National Science Foundation-supported Using Data Project, we find much to celebrate. Over the last few years we have applied the Using Data Project in schools that are serving among the poorest children in this country—children from Indian reservations in Arizona, the mountains of Appalachia in Tennessee, and large and mid-size urban centers in the Midwest and West.

A few years ago some of these children were simply passing time in school with "word search" puzzles or other time fillers; some were permanently tracked in an educational system that doled out uninspired, repetitive curriculum. Some of the schools in which we worked had not one single student pass the state test, and the vast majority were performing at the lowest proficiency level.

Today schools implementing the Using Data Process have narrowed the achievement gaps between students with exceptional needs and general education students in all content areas and grade levels; tripled the percentage of African Americans proficient in middle school mathematics; demonstrated significant and steady gains in mathematics in elementary, middle, and high schools; and cut the failure rate of Native American children in half. Students in these schools are reaching proficiency on assessments in record numbers.

Improving schools give us hope. They dispel the myth that some students cannot learn. They inspire us to even greater levels of commitment to take on the biggest problems that schools face: cultures rife with resignation, isolation, stagnation, and mistrust; racist and classist attitudes and practices that result in failure to see and serve students who do not look or act like the dominant culture; outdated and inexcusable instructional practices; teachers who are not as well prepared to teach to rigorous content standards; and ineffective and dangerous uses of student data.

With our collective decades of work in school improvement, we do not underestimate the grip these problems have on schools' and educators' spirits. Yet we have witnessed every one of these seemingly insurmountable barriers begin to fall away when school teams learn to work together and use data and research to identify and tackle the causes of student failure.

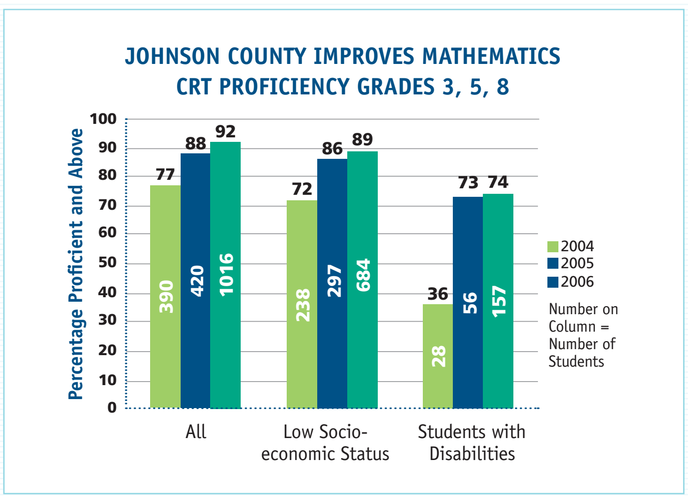


Figure 1 *Math and reading scores in Johnson County, Tennessee, improved in grades 3, 5, and 8, nearly eliminating the gap between regular education and special education students.*

We know it can be done. Our new book, *A Data Coach's Guide*, is designed to inspire and help you as you use collaborative inquiry to achieve similar or even greater success in your own schools.

How the Book Came About

Beginning in 2003, the Using Data Project, a collaboration between TERC and WestEd, set out to develop, pilot, and field-test a program to provide educators with the skills, knowledge, and dispositions to put school data to work to improve teaching and learning and close achievement gaps.

The project conducted two national field tests. While our efforts focused on mathematics and science improvement, the schools quickly applied the Using Data Process to all other content areas. Field-testers gave us immediate feedback on the materials and, in several cases, took the materials and implemented them in schools in which they were working in Los Angeles, California; Colorado Springs, Colorado; and Johnson County, Tennessee (Figure 1). Through the rich experiences and work with our partner schools, the project gleaned a wealth of technical and practical knowledge about how to prepare Data Coaches to work with teams in diverse settings, from large urban areas to mid-size cities to small rural schools. This book is the product of that work.

Get Ethical, Get Technical: The Purpose of the Book

Author and cultural proficiency expert Franklin CampbellJones says, "Get ethical before you get technical."[1] School improvement without will and moral purpose—without a genuine commitment to all students—is an empty exercise in compliance that, in our experience, can do more harm than good. We have seen educators use data to "more accurately" track students, further widening the opportunity-to-learn gap. Avoiding data-based disasters is not a technical matter. It is an ethical matter that begins with passion and determination.

What ignites the Using Data Process is the appetite, choice, and determination to serve every child as if he or she were our own; a mindfulness of the awesome influence we have in the children's lives that we touch; and a commitment to use that influence to produce the best possible results for every one of them. Our first driving purpose for this book is to contribute to dramatic and permanent improvement in the way schools go about their business so that they make that level of positive difference in students' lives. Our second purpose is to strengthen your resolve and the resolve of others whom you work with to do whatever it takes to educate every child to the peak of his or her capacities.

Our third purpose is to "get technical"—to build skills and knowledge about how to lead a process of collaborative inquiry with school-based data teams. In the last few years,

USING DATA PROJECT PARTNERS

- Clark County School District (Las Vegas, Nevada) in collaboration with the Clark County Local Systemic Change Initiative, Mathematics and Science Education
- Arizona Rural Systemic Initiative, based at the Indian Affairs Program at East Stark County Mathematics and Science Partnership, Canton, Ohio
- Education Development Center's K-12 Science Curriculum Dissemination Center

educators have been called upon to do work they have never done before and were, in most cases, never prepared to do, including apply principles of cultural proficiency to school improvement; understand and draw sound inferences from data; accurately identify root causes of problems that the data surface; and so much more. This book addresses that capacity crisis by providing you with detailed, technical guidance in how to use data to engage in systematic and continuous improvement.

Behind the Book: Our Assumptions

The Using Data Process places a major emphasis on surfacing and engaging in dialogue assumptions. Therefore, any discussion of the book would not be complete without a clarification of the assumptions we held as we developed the entire process. We hope Data Coaches will use these assumptions as catalysts to clarify their thinking and to create dialogue with their teams.

ASSUMPTION 1: *Making significant progress in improving student learning and closing achievement gaps is a moral responsibility and a real possibility in a relatively short amount of time—two to five years. It is not children's poverty or race or ethnic background that stands in the way of achievement; it is school practices and policies and the beliefs that underlie them that pose the biggest obstacles.*

Federal and state policies will come and go, but as Michael Fullan[2] reminds us, "You can't mandate what matters." What matters is educators' deep responsibility for the learning of every child. This assumption implies a shift from a compliance mentality—a sense of external accountability, something someone is making us do—to a sense of internal and collective responsibility. We believe that it is impossible to use data as a lever for change without talking about race, class, and culture and our beliefs about the capabilities of children. The possibility to dramatically improve the learning of traditionally underserved students has been demonstrated time and again. It is the silence about these issues that has kept us from confronting problems and taking action.

ASSUMPTION 2: *Data have no meaning. Meaning is imposed through interpretation. Frames of reference—the way we see the world—influence the meaning we derive from data. Effective data users become aware of and critically examine their frames of reference and assumptions.[3] Conversely, data themselves can also be catalysts for questioning assumptions and changing practices based on new ways of thinking.*

If one holds the view that whether or not students learn is the student's responsibility and not that of the teacher, one might then look at a student's poor performance on assessments and conclude that it is entirely the student's fault and that there is nothing to be done to improve teaching. For example, if one believes that African American students are not as capable as white students, then data that reveal an achievement gap between these groups do nothing but confirm that belief. The reaction is complacency or resignation. On the other hand, when one is open to critically examining assumptions, data can be a catalyst to discard old frames of reference and embrace new ones.

ASSUMPTION 3: *Collaborative inquiry—a process where teachers construct their understanding of student-learning problems and invent and test out solutions together through rigorous and frequent use of data and reflective dialogue—unleashes the resourcefulness and creativity to continuously improve instruction and student learning.*

"The staff at Wendell Williams phoned yesterday screaming. They received their CRT results...all scores, all grade levels, and all subjects went UP!"

— FLORENCE BARKER, PRINCIPAL AND DATA COACH, CARTWRIGHT ELEMENTARY SCHOOL, CLARK COUNTY SCHOOL DISTRICT, NEVADA

Teachers possess tremendous knowledge, skill, and experience. Collaborative inquiry creates a structure for them to share that expertise with each other, to discover what they are doing that is working and do more of it, and to confront what isn't working and change it. When teachers generate their own questions, engage in dialogue, and make sense of data, they develop a much deeper understanding of what is going on relative to student learning. They develop ownership of the problems that surface, seek out research and information on best practices, and adopt or invent and implement the solutions they generate.

ASSUMPTION 4: *A school culture characterized by collective responsibility for student learning, commitment to equity, and trust is the foundation for collaborative inquiry. In the absence of such a culture, schools may be unable to respond effectively to the data they have.*

Long before state tests, plenty of data were available to let us know some students were not learning—students going through day after day of school without being engaged, poor grades, poor attendance, and high dropout rates. However, in the absence of a collaborative culture where everyone takes responsibility and is committed to improving student learning, educators literally could not respond to the data. In schools that do have this "response-ability," responsibility for student learning is enacted as part of the daily work of teachers. A hallmark of such high-performing cultures is a commitment to equity, which requires a high level of trust. Educators must trust each other enough to discuss "undiscussables" such as race, reveal their own practice and mistakes, root for one another, and face together the brutal facts that data often reveal.[4]

ASSUMPTION 5: *Using data itself does not improve teaching. Improved teaching comes about when teachers implement sound teaching practices grounded in cultural proficiency—understanding of and respect for their students' cultures—and a thorough understanding of the subject matter and how to teach it, including understanding student thinking and ways of making content accessible to all students.*

It is easy to get swept away in the data-driven mania provoked by federal and state education accountability policies, where data can sometimes seem to be an end in themselves. But test results, lists of "failing" schools, bar graphs, tables, proficiency levels, even student work, do nothing by themselves to improve teaching unless they spark powerful dialogue and changes in practice. The data are just the tip of the iceberg, alerting us to problem areas and reminding us that what lies beneath is what counts—the curriculum, instruction, assessment, and professional development practices that will improve student learning. Data use is not a substitute for the hard work of improving instruction.

ASSUMPTION 6: *Every member of a collaborative school community can act as a leader, dramatically impacting the quality of relationships, the school culture, and student learning.*

Marzano, Waters, & McNulty[5] identified 21 leadership behaviors correlated with student academic achievement. Virtually all of these 21 responsibilities, which include celebrating accomplishments, challenging the status quo, fostering shared beliefs and community, staying focused on goals, and communicating ideas and beliefs, are functions of Data Coaches and data team members as well as of school and district administrators. Data use is no longer a specialty of the assessment or central office or the principal. Everyone in the school can and should understand and use data in ways that contribute to instructional improvement.

"When our middle school mathematics data team received their most recent state achievement test results, they broke into cheers and tears. That's ownership!"

— PAM BERNABEI-RORRER, MATHEMATICS AND DATA COACH, CANTON CITY, OHIO

A DATA COACH'S GUIDE AND THE USING DATA WORKSHOPS

Show You How To:

- Design, implement, and sustain a district-wide (or project-wide) program of continuous improvement in diverse settings.
- Prepare Data Coaches to lead data teams in collaborative inquiry and high-capacity uses of data.
- Keep the focus on equity and closing achievement gaps.
- Increase the power, focus, and effectiveness of professional communities.
- Use data as a catalyst to powerful conversations about race/ethnicity, class, educational status, gender, and language differences.
- Get staff excited about using data regularly and collaboratively.
- Apply robust tools for making sense of data.
- Connect data use to instructional improvement and learning results.

Inside the Guide

A Data Coach's Guide is both a guidebook and a CD-ROM toolkit that provides step-by-step notes and tested tools for setting up and leading your data team. Inside the book you will find Task-at-a-Glance tables; background information; directions for materials and data preparation; detailed step-by-step procedures; illustrative data; and real-life examples of data teams in action.

The first two chapters help you lay the necessary groundwork for successfully implementing the Using Data Process. They explain the collaborative inquiry process; how to establish conditions for success; and how to prepare Data Coaches to engage with their teams. These chapters also discuss how to build understanding and support for the process among parents, school boards, faculty, and other members of your school community.

The heart of the book, Chapters 3 through 7, describe in detail how Data Coaches facilitate each of the five components of collaborative inquiry that are essential to the Using Data Process: building the foundation; identifying a student learning problem; verifying causes; generating solutions; and implementing, monitoring, and achieving results. These chapters present a sequence of 19 tasks for Data Coaches to carry out with their teams. For example, tasks in Chapter 4, Identifying a Student-Learning Problem, focus on drilling down into state CRT [criterion-reference test] data, student work and local assessments; while in Chapter 6, Generating Solutions, the tasks include using a logic-model to identify best outcomes and creating plans to meet a specific student learning goal.

The final, inspirational chapter, Clark County, Nevada: Collaborative Inquiry In Action, shows you the whole process over three years in one district and school. With commentary from the Data Coach and Principal involved, you'll learn about the challenges the school faced and how they surmounted them.

A Data Coach's Guide also includes a CD-ROM with all the tools and materials you need to successfully implement the Using Data Process with your team. It contains Excel data templates, PowerPoint slides, sample agendas, protocols for engaging in data-driven or equity dialogues, group process tools for establishing roles, tools for analyzing data; forms for documenting your work; and much more. The materials are organized by chapter and task, making it simple to access the resources you need at every stage of the process.

Many School Contexts, Multiple Entry Points

Because every school context is different, we designed this book to be navigated in various ways depending on your needs. It is not necessary or even recommended to conduct every activity with every data team. Instead, customize the process by considering the knowledge, skills, beliefs, and experiences of your data team and the time and data available. We have included a variety of assessments of data literacy and school practices that will help you tailor your own approach to these materials. Use the book with your context in mind and find the best fit between your purpose and our product.

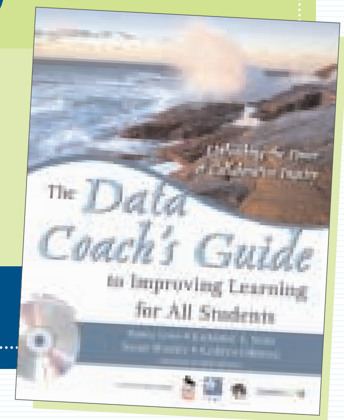
For example, a Data Coach who wants to follow the entire process might choose to go chapter by chapter, following what we have laid out in a comprehensive, sequential, and structured way. A reader who already has an established continuous-improvement process in place might strengthen that process by focusing on one or two components of collaborative inquiry and choosing chapters accordingly. Readers who want to see the whole picture before getting into the details of the process could start off by reading Chapter 8, the case study about Clark County, Nevada. Or, some readers may want to go directly to the Toolkit on the CD-ROM and scan for specific tools to use with their data teams or faculty. The Using Data Project also offers workshops based on the materials contained in the Guide for districts looking to implement the process on a large scale.

Whatever pathway you take, please use this guide to inspire your own creativity and to unleash the power of collaborative inquiry to make a better future for all of our children.

All photos courtesy of the Using Data Project archives.

A Data Coach's Guide to Improving Learning for All Students: *Unleashing the Power of Collaborative Inquiry*

By Nancy Love,
Katherine E. Stiles,
Susan E. Mundry,
Kathryn DiRanna



Available from: Corwin Press
www.corwinpress.com

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For more information about the Using Data Project at TERC, contact Diana Nunnaley, Using Data Project Director, diana_nunnaley@terc.edu. To learn how your school can benefit from TERC's Using Data Workshops, see page 2.

Featured New Projects

TERC researcher LuAnn Dahlman worked with the ANDRILL science team in Antarctica.

Antarctica's Climate Secrets

TERC researcher LuAnn Dahlman recently worked with the ANDRILL science team in Antarctica and is now developing materials to bring the science behind this international geology project to informal science venues. The project's "flexhibit" is a downloadable set of hands-on activities, posters, and podcasts that groups use to host a community science event for the International Polar Year. The project will also feature a NOVA documentary developed by Nebraska Educational Television. *Funded by the National Science Foundation through a grant from University of Nebraska-Lincoln.*

Bridging NSF Science Research, Education, and Innovation

This project has created a prototype web site, and will provide a research paper and a recommendations report, to lay the groundwork for new National Science Foundation (NSF) initiatives that seek to bridge science research, education, and innovation more explicitly. The prototype site will provide a model to highlight the impact that NSF projects have on fueling innovation in the States. We invite your feedback on the prototype web site at **http://innovation.terc.edu**. *Funded by the National Science Foundation.*

Engaging Blind Students in Geosciences

TERC will make inquiry-based Earth science education more accessible to blind students, using multi-modal delivery systems. The pilot program is focusing on weather forecasting, adapting real-time satellite, radar, and surface weather analysis images to represent data as graphics on tactile paper. Specialized audio software will represent numerical trends, such as temperature and pressure data, as sonic graphs. TERC is also creating learning activities that make use of these resources. *Funded by the National Science Foundation.*

I Believe in Math

TERC is developing resource kits to integrate math into activities such as cooking and gym games. The three kits are created for use in child care centers, in after-school and summer programs, and at home. Kits will be provided free of charge to caretakers of IBM employees' children. *Funded by IBM Global Work/Life Fund.*

Math Off the Shelf

In collaboration with national public library leaders, TERC is making math a visible and fun part of library programming for elementary grades children and their families. The projects is developing materials for story times and crafts that integrate literacy and math, and supporting children's librarians in outreach to local after-school programs. The project will provide materials online, in English and Spanish, free of charge. *Funded by the National Science Foundation.*

Pathways to Algebra

This project is hosting an invitational conference that will bring together 30 distinguished mathematics educational researchers, educators, and research mathematicians to discuss data, findings, and claims regarding young students' ability to reason algebraically and begin to use algebraic representations. The aim is to achieve a grounded discussion about the place of algebra in early mathematics instruction. *Funded by the National Science Foundation.*

Get Involved

Earth Science by Design

Register for a three-day leadership conference, June 23–25, 2008. Learn the fundamentals of ESBD and how to facilitate this year-long professional development program, which builds the capacity of middle and high school teachers to teach for deeper, enduring understanding in Earth and space science. Visit **www.esbd.org** or email harold_mcwilliams@terc.edu.

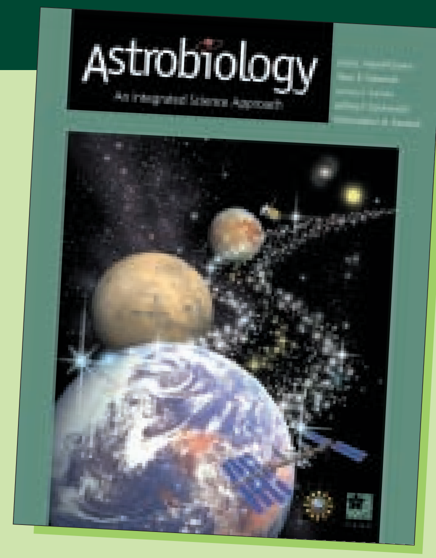
Online Science-athon

Teachers of students in grades 4-8 are needed to test virtual and physical versions of the Marble Roll and Catching Sunshine. Visit the Science-athon web site at **http://scithon.terc.edu** or email judy_vesel@terc.edu.

EMPower Workshops

The EMPower professional development workshops support teachers who want to breathe life into the "remedial math" classes offered in alternative high school programs, Adult Basic Education and GED programs, and developmental college. These hands-on workshops are accessible to instructors of all "math comfort" levels. Visit **http://adultnumeracy.terc.edu** or email empower@terc.edu.

ASTROBIOLOGY:
An Integrated Science Approach



TERC introduces a full-year, integrated science curriculum coinciding with NASA's recent missions to find life beyond our planet. The inquiry-based course combines biology, chemistry, Earth and space science, and physics and leads students to explore intriguing questions around the origin, search for, and future of life in the universe. Features include:

- 600-page full-color Student Guide
- Deep collection of teacher resources and technological tools
- Teacher's Guide designed for instructors unfamiliar with teaching integrated science courses
- Web site with resources and links used within the curriculum

Published by It's About Time. www.its-about-time.com/htmls/astro/astro.html

SCIENCE BY DESIGN

Can you build a catapult that can hit its target consistently? Can you design a model for a faster boat hull?

The challenges presented in the Science by Design series let high school students use easy-to-find, inexpensive materials to grapple with concepts such as heat transfer, buoyancy, elasticity, and insulation. Science by Design supplements classroom science work and has garnered praise for encouraging students to see the connections between everyday items and the project-based activities.

- ▸ **Construct-a-Greenhouse**
- ▸ **Construct-a-Glove**
- ▸ **Construct-a-Boat**
- ▸ **Construct-a-Catapult**

Published by NSTA Press. www.nsta.org/store

Investigations Workshops

for Transforming Mathematics

Lee Kilpatrick

For over ten years, those attending Investigations Workshops have experienced mathematics learning and teaching in ways that have transformed their own teaching and understanding of how children learn mathematics. These professional development workshops are for teachers, administrators, and mathematics leaders in schools and districts implementing the *Investigations in Number, Data and Space®* curriculum.

A major revision of the curriculum (the second edition) was launched for the 2007-2008 school year. Investigations Workshops support users of either the 1st or 2nd edition of *Investigations*.

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Since 1997, the workshops have reached over 22,000 teachers in 34 states across the country, in both large urban districts and small rural communities.

"I still get chills when I use a quote from one of my teachers; 'I came with anxiety and I am leaving with excitement!' That speaks volumes for what took place during the week!"

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