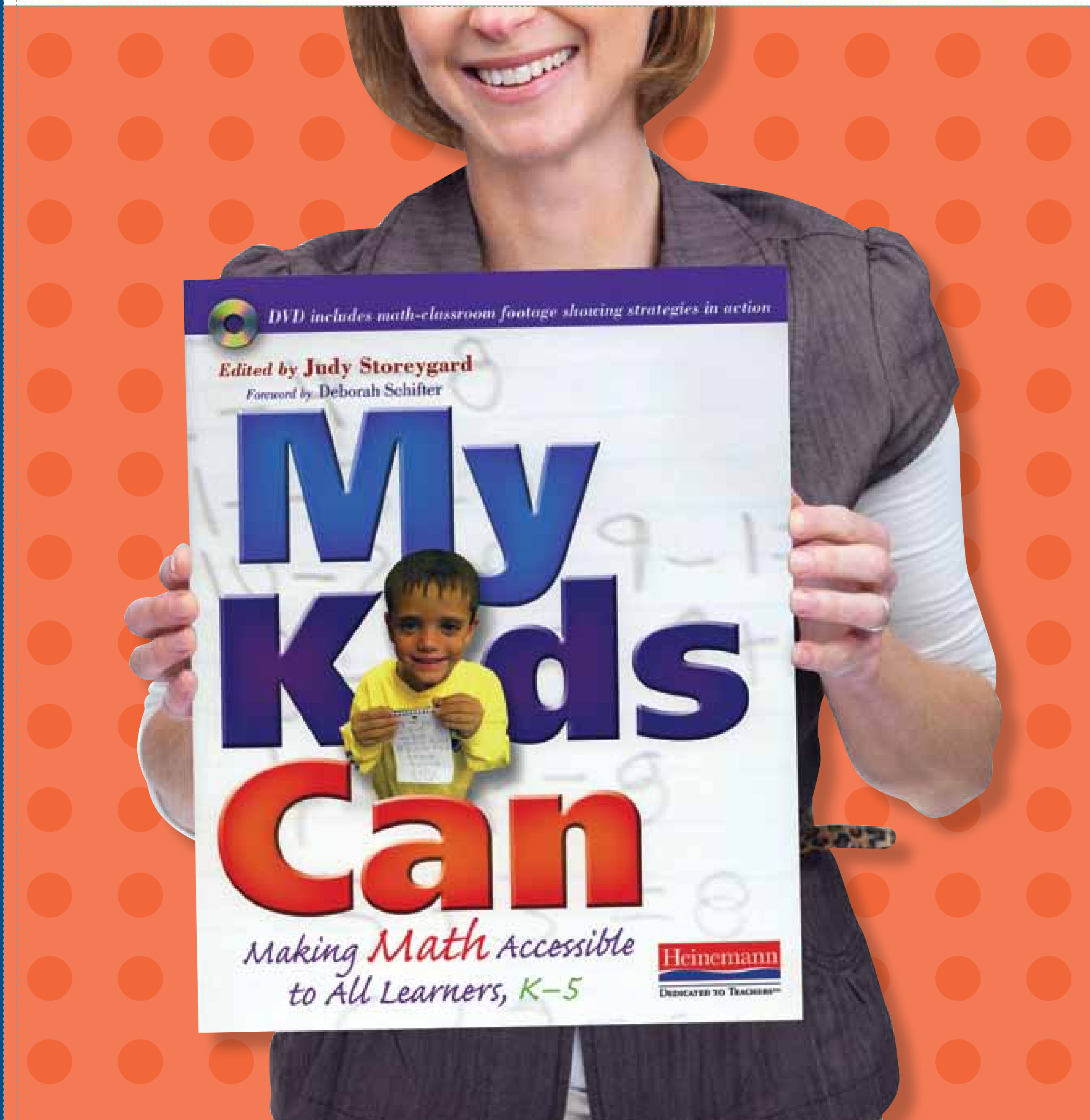
Hands On!

Winter 2011

A magazine for mathematics and science educators

TERC



"**All teachers of mathematics face the challenge of reaching the range of students in their classroom.** Many teachers feel especially daunted by the task of helping students who are struggling as learners. Faced with a student who lacks confidence, doesn't know how to interpret a task, and loses focus, what is a teacher to do? *My Kids Can* is an important resource for teachers who are ready to tackle this challenge."
— Deborah Schifter, from the Foreword to *My Kids Can* (CONTINUED ON PAGE 4)

Investigating Astronomy

The first comprehensive astronomy textbook written specifically for high school students.

By Jeffrey F. Lockwood, Jodi E. Asbell-Clarke, Erin M. Bardar, and Teon E. Edwards

This landmark text includes all the major topics in an astronomy course supplemented with hands-on investigations and web-based tools and software. The student guide has six major themes:

- Investigating Motions of the Sky
- Investigating the Sun-Earth-Moon System
- Investigating Planets
- Investigating Tools of Astronomy
- Investigating Stars
- Investigating the Universe

The first three units cover observations humans have made from Earth and the mechanics and characteristics of objects within our solar system. The second three units cover how astronomers explore the cosmos, the nature of stars, and the size and extent of the universe we live in.

Each unit is structured around activity-based “Explorations” that prepare students for “Challenges”—projects that make use of all the information presented in that unit. Students make, justify, and revise scientific claims based on supporting evidence.

Published by It’s About Time

To learn more about *Investigating Astronomy*, go to http://www.its-about-time.com/htmls/astronomy/index.html

Contents

letter

At TERC, the staff of educators, researchers, scientists, and mathematicians continuously research ways to improve the teaching and learning of science. These efforts always focus on designing programs that help educators create more effective learning environments, where every student is fully engaged.

In this issue of *Hands On!*, we highlight a few of the professional development efforts that TERC is conducting. The teacher resource book *My Kids Can* (cover article) grew out of years of research that brought together special educators and classroom teachers to develop strategies that improve learning for students who struggle with mathematics. Special education and classroom teachers also collaborated in TERC’s Lesson Study for Accessible Science project. One project participant reflects on her experiences beginning on page 18.

Advances in science and technology have changed what teachers need to teach and the ways they can learn from each other. BioTeach (page 15) is a professional development effort aimed at increasing students’ knowledge and interest in biotechnology. And on page 8, Joni Falk and Brian Drayton discuss critical questions that impact the design of electronic professional learning communities.

— *Kenneth Mayer*

features

departments

Executive Editor
Kenneth Mayer

Contributing Editor
Peggy Kapisovsky

Editorial Assistant
Kacy Karlen

Designer
Carol Maglitta, one[visual]mind

Hands On! is published by TERC, a not-for-profit education research and development organization dedicated to improving mathematics, science, and technology teaching and learning.

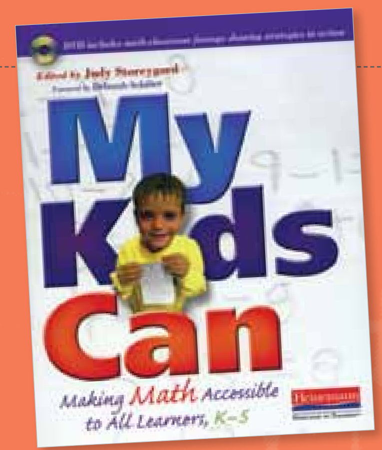
Copyright © 2011 by TERC. All rights reserved. No part of this publication may be reproduced without written permission. Contact Ken Mayer, TERC, 2067 Massachusetts Avenue, Cambridge, MA 02140, 617.873.9600, ken_mayer@terc.edu. *Hands On!* is available at www.terc.edu.

Photo credit: Cover, istockphoto.com

All opinions, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the funding agencies.

ISSN 0743-0221

My Kids Can



Making Math Accessible to All Learners, K–5

By Judy Storeygard

The following is an excerpt from *My Kids Can: Making Math Accessible to All Learners, K–5*, edited by Judy Storeygard. Copyright (c) 2009 by TERC, Inc. Reprinted by permission of the publisher, Heinemann, Portsmouth, NH.

NCTM Standards-based instruction might be fine for most students, but students who are struggling with mathematics must be told what to do.

When my colleague, Cornelia Tierney, and I were working on Bridges to Classroom Mathematics, a National Science Foundation funded professional development project focused on the implementation of NCTM Standards-based curricula, we heard statements like the one above from administrators across the country. We, however, strongly believe that all children can learn to make sense of mathematics and deserve the opportunity to do so. With funding from the National Science Foundation, we developed the Accessible Mathematics project. This project brought together special educators and classroom teachers to develop principles and strategies to improve the mathematical learning of students who struggle with mathematics.

For two years, TERC researchers met regularly in an action research group with sixteen teachers, both special educators and classroom teachers working together to present and discuss episodes from their classrooms, plan next steps in their investigations of students' learning, and document what worked. The audience for this work is primarily teachers, either those who are already working with young students or those who are preparing to teach mathematics in the elementary grades.

All of the Accessible Mathematics teachers made sure that their students knew that they expected them to support one another as learners and that they expected their students who struggled to learn along with their peers. They created a culture based on respect and acceptance of differences in which students felt safe to take risks and to admit confusions. The teachers listened carefully to students' thinking, analyzed how students made sense of the mathematics and why they might be confused, and chose representations that could help the children solve the problem. During our seminar meetings, they talked about what students knew as well as what they didn't know.

As our researchers and teachers collaborated, they came to identify five actions that are critical to teaching mathematics to students who struggle:

- Make mathematics explicit
- Link assessment and teaching
- Build understanding through talk
- Expect and support students to work independently and take responsibility for their own learning
- Work collaboratively

These five principles provide the organizational structure for this collection. A section of the book is devoted to each principle and consists of an introduction with questions to consider, followed by chapters that describe teachers' practices through both written and video episodes that relate to the particular theme of the section. The goal is to give teachers examples of strategies that they can implement in their mathematics to improve the learning of their students who are struggling.

It will become quite evident as you read the essays that these principles overlap. An essay has been included in a particular section because of its primary theme, but you will notice similarities among all of the essays. Any given essay may have elements of several principles because all five characterize good teaching.

1 Making Mathematics Explicit

The teachers whose essays and videos appear in this section take an active role in helping students who struggle to access mathematical concepts. They analyze activities ahead of time to identify what concepts might be difficult for their students who struggle, pre-teach necessary skills such as vocabulary, and refer to prior work that the class has completed, such as posting students' strategies in the room. They are purposeful in every teaching move they make, for example, calling on students to share whose strategies are mathematically sound and can help others understand the underlying concepts, and asking that extra question that might seem obvious, but that they know is necessary to build understanding. Providing and referring to specific resources, such as 100 charts and manipulatives, is another strategy these teachers use, and to build flexibility they highlight the connections among different representations. When they find that they have students who need support with particular skills, they plan an intervention, pulling students who are struggling into a guided math group.

These teachers also understand that expectations for doing mathematical work must be clear. Too often expectations for successfully completing a task are indirect. For example, when teachers ask students to explain their answer, unless the expectations have been established that an explanation includes elements such as a sequence of steps and an accurate use of a representation, students, especially those without a solid mathematical foundation, cannot fulfill the request. Being clear about expectations and goals helps all students, but explicit teaching is particularly important for fragile learners.

2 Linking Assessment and Teaching

The essays in this section illustrate that assessment must be ongoing and inform planning, as opposed to being used only to measure learning at the end of a unit of study. Assessing students who struggle involves finding out about their strengths as well as their weaknesses and planning accommodations accordingly. Throughout this section, you will see evidence of teachers' deep knowledge of elementary school mathematics content and how mathematical ideas develop. This knowledge forms the basis for their teaching and assessment decisions. Although finding time for ongoing assessment is difficult, because these teachers had specific goals in mind, they were able to do assessment in a manageable period of time: taking notes as they observe children working in small groups, remembering children's comments during whole-group discussions, or meeting with students for targeted one-on-one interviews.

3 Building Understanding Through Talk

In recent years, there has been an acknowledgment of the importance of talk in elementary mathematics classrooms. According to the NCTM standards, mathematics instruction should allow students to:

- Organize and consolidate their mathematical thinking through communication
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
- Analyze and evaluate the mathematical thinking and strategies of others
- Use the language of mathematics to express mathematical ideas precisely (NCTM 2000)

Yet teachers find that including all their students in discussion is challenging. We were often asked, "I want to include all students in class discussions, but some of my students who struggle tune out during meetings. What can I do to make them feel included?"

In this section, teachers describe how they establish community norms so that each student feels valued and safe to participate. During whole-group discussions, these teachers actively involve their students in doing mathematics, making connections to prior work, and targeting powerful strategies that are accessible. Critical work also takes place well before the discussion. Teachers figure out ahead of time where their students might have difficulty following the conversation and plan accommodations accordingly, such as including examples of students' work from prior sessions or providing concrete materials or representations as an entry point. Sometimes the accommodations include pulling together a small group to preview the day's activity so they can follow and participate during the whole group time or rehearsing one of their strategies so they might later share in the whole group. This extra practice is often key to supporting these students in building their mathematical understanding through talk.

4 Taking Responsibility for Learning

The teachers who wrote the essays in this section found that their students who struggle often do not see themselves as capable learners. These students tended to not ask for help, participate in groups, or begin or complete work independently. This "learned helplessness" frequently results from experiences of failure and low expectations. The authors of these essays believe that their students who struggle can learn, and they find strategies to help them do so. They developed routines to help students feel comfortable and get them started, beginning with making sure the students know what they are being asked to solve. Sometimes this involved retelling a story problem or making accommodations so that the students were able to make sense of the mathematics. The teachers also engaged the students in evaluating their own learning, asking them to answer questions such as "Did I actively participate in learning? Did I use everything I know to help myself with the problem?"

> **"They created a culture based on respect and acceptance of differences in which students felt safe to take risks and to admit confusions.**
>
> **The teachers listened carefully to students' thinking, analyzed how students made sense of the mathematics and why they might be confused, and chose representations that could help the children solve the problem."**

This section is closely tied with the Linking Assessment and Teaching section, because when teachers assessed their students of concern, they often found out that the students' lack of confidence stemmed from gaps in their learning. They used assessment to find students' strengths to help build both their confidence and their mathematical understanding.

5 Working Collaboratively

During the course of our project, we were fortunate to collaborate with Karen Mutch-Jones, a researcher studying collaboration between classroom and special education teachers. Ms. Mutch-Jones' data (Mutch-Jones, 2004) revealed that collaboration can have a powerful impact on the classroom community:

- All students form a relationship with and seek help from both teachers instead of seeing the special education teacher as the teacher for *those* kids.
- Expectations for learning behavior (e.g., paying attention, participating in the group) during math class are the same for all students.
- Teachers help each other to establish fair, yet high expectations for learning mathematics for all students.
- All students have access to a standards-based curriculum, to learn mathematics concepts with understanding, and to develop strong problem-solving strategies.

Mutch-Jones' findings showed that collaboration also led to the following benefits:

- Teachers gained a broader or deeper understanding of mathematics content and curriculum.
- Teachers learned to ask each other and their students better questions about mathematical thinking and math curriculum.
- Teachers expanded their ways of thinking about student abilities and needs.

The essays in this section illustrate both the benefits and the challenges of collaboration. Many of the barriers are structural. The schedules of special education teachers and classroom teachers may not overlap, and their responsibilities may differ, particularly in regard to administrative responsibilities. Opportunities for professional development and the amount of mathematics instruction teachers received as part of their preparation are often not the same, with the special educator being offered far fewer courses and inservice programs in mathematics. However, the teachers who wrote these essays were able to meet regularly to plan for and reflect on the students they taught in common. They analyzed student work and conversations to decide on next steps, determined which teacher would take responsibility for what aspect of teaching, and decided how they would assess what the students knew. All parties concerned, whether in a co-teaching or pull-out situation, felt positive about the advantages of the collaborative relationship in terms of what they learned from each other and what students gained as a result of their coordinated effort.

The goal of this resource is to immerse you in the classrooms of skilled practitioners so that you have models and examples of what it means to help all students make sense of mathematics. These teachers do not take the "ten steps to success" approach. Instead, their essays are designed to give you a window into their thinking, addressing questions such as:

- How do you get students who are not working independently to find a starting place and learn to explain their thinking?
- When special educators and classroom teachers collaborate, how do they plan? What is it like when they both work with students who struggle?
- How do teachers take the time to engage in ongoing assessment? What happens with the rest of the class?
- How do teachers orchestrate the sharing of strategies—isn't it confusing for students who are struggling?
- When students are so far behind, what do you help them focus on in a lesson?

The purpose of analyzing these written and videotaped episodes is not to look at whether what the teacher is doing is right or wrong, but instead to consider the decisions a teacher makes, why he or she might have made those decisions, and what effect those decisions might have on the students' learning. The complexity of the process is always apparent. Many of these teachers have years of experience developing the strategies you will see and read about. Some of the newer teachers write about how they are learning to teach their struggling learners effectively. We hope you will be able to apply or adapt their principles and actions to your own classrooms and teaching situations. We also hope that you will see how the principles and actions described here benefit all students, not just those who struggle. As one of our teachers explained:

"What we've learned from working with our students who are struggling has made us better math teachers for all of the kids. Ideas about sequencing, about not being so quick to explain, about really insisting that kids figure some things out for themselves, that models that work for some kids don't work for others… Teaching them (students who struggle) effectively IS teaching the class effectively."

REFERENCES

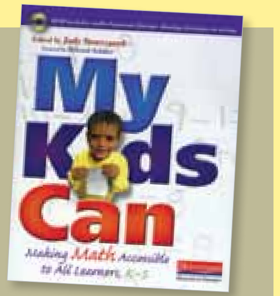
Mutch-Jones, K. (2004). Collaborative insights: The work of general and special educator pairs in inclusive mathematics classrooms. Unpublished doctoral dissertation, Harvard University Graduate School of Education, Cambridge, MA.

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

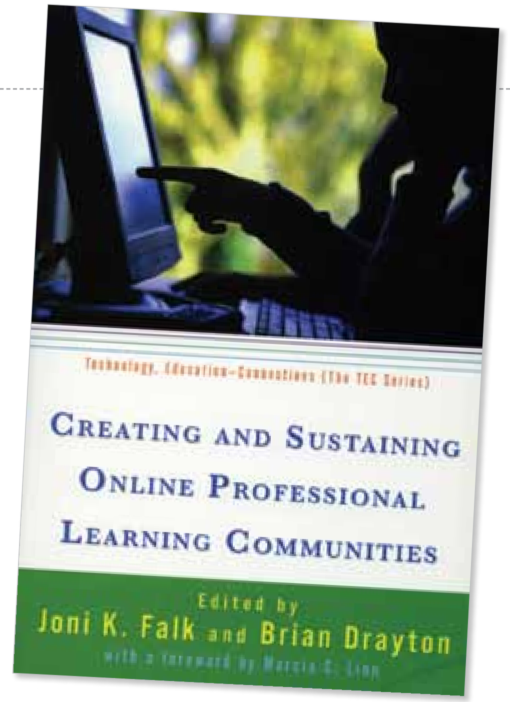
***Judy Storeygard** is a project director at TERC, with a long-term interest in students with special needs and teacher development. judy_storeygard@terc.edu.*

The Accessible Mathematics project at TERC was funded by the National Science Foundation HRD-0435017

My Kids Can: Making Math Accessible to All Learners, K–5
is a guide written by teachers for teachers. The book and accompanying DVD are available from Heinemann.
www.heinemann.com, 800.225.5800



Creating and Sustaining Online Professional Learning Communities



By Joni K. Falk and Brian Drayton

(The following excerpt is from the Introduction to *Creating and Sustaining Online Professional Learning Communities*, edited by Joni K. Falk and Brian Drayton. Reprinted with permission from Teachers College Press.)

For the past two decades a growing number of professional developers, educators, web designers, and programmers have collaboratively developed electronic communities to facilitate professional learning in the areas of mathematics and science. This book presents the work of a group of trailblazers who have been engaged in the creation of such communities over a long period of time. In sharing their insights and decisions, they cast light on the building and scaffolding of many aspects of online communities: content selection, creation and management, site architecture, administrative structures, tools and interactive features to be deployed, facilitation of discourse, and the development of online leadership. These developers have been learning from their experience, assessing the success of their projects, and at the same time engineering future projects to take advantage of a greater suite of interactive functionalities, faster data transmission rates, nearly ubiquitous access, and a growing pool of users with ever-greater web sophistication and expectations.

When the authors in this volume met, we found that we shared certain ideas that influenced our work and explored how these ideas contributed to the development of very different online professional development environments. Our discussion, and the chapters that emerged in this book, related to four groups of questions.

1. How do the content and the context (online course, virtual conference, community forum) affect the type of professional experience that one encounters?

One way in which these communities vary is in the nature of their content. The narratives make clear that the content present on a site is shaped by several different characteristics, including the site's community, purpose, and processes. Indeed, the contrasts among these sites are to an interesting degree a matter of relative emphasis, despite obvious specific differences.

These sites differ in the degree to which the content is constrained. For example, Rubin and Doubler, in their Investigating Physics course, cover a well-defined corpus of knowledge related to the basic physics of motion. The Math Forum, while focused on Mathematics teaching and learning, covers a broad variety of topics for a broad array of constituencies. Some are parents; others, students who enjoy doing math; still others, educators seeking better ways to represent a lesson. Perhaps furthest along this spectrum, Bruce in Chapter 2 offers a toolkit and a philosophical framework through which very different constituencies can explore unrelated interests.

Another dimension that affects the content is the degree of emphasis on the sharing of resources as opposed to the sharing of craft knowledge. The latter seeks to encourage practitioners to share information, techniques, and subject matter of specific importance to the work in which they are immersed. The role of this in a particular community may not be evident at first glance. In MERLOT (McMartin), for example, what strikes the visitor first is the collection of resources being exchanged, but the value of these resources is significantly enhanced by the annotations and comments from community members about how they have used the resources, including such qualities as potential effectiveness, as a teaching tool and ease of use for students or teachers. In a related vein, the visitor to MSPnet might be struck by the wealth of resources on math and science reform within the library and resource centers. However, members on MSPnet would use private forums to exchange draft work in progress, challenges, and strategies with their colleagues.

In addition to variations in content, the professional online experiences represented in this book provide multiple contexts within which discourse is facilitated. Each of these sites make use of "implementation metaphors," which enable the user/participant to quickly grasp what participation can mean, what kinds of interactions will be available, and what sort of topics may be offered. For example, people who attend a "virtual conference," as described by Falk, Lee, and Drayton, bring from their experience of face-to-face conferences an expectation that there will be ways to interact with peers around their work, as in a poster presentation; there will be presentations from leaders in the field, as in keynote addresses; there will be thematic, focused exploration of common problems in the field, as in the form of panel discussions; and there will be conversations. Judicious use of such expectations enables the user to feel at home with the electronic environment quickly and efficiently. In the case of an online course (Rubin and Doubler), schedules, grades, feedback from teachers, and so on provide incentives to full participation, as well as guidance about some specific ways to interact. The Inquiry Learning Forum (Scheckler and Barab) builds on spatial imagery to enable teachers to "tour" one another's classrooms as one more channel of exchange. These metaphors in combination enhance the quality and quantity of information and meaning that are available to participants.

2. How is professional development influenced by different site architectural structures, choices of collaborative tools, models for facilitation of interaction, and administrative structures?

The designer's vision of the purpose of the professional development, as well as the nature of the content and context, as explored above, influence the suite of collaborative tools that are employed. For some—e.g., the Math Forum (Shumar) and MERLOT (McMartin)—text exchanged through discussions and the posting and sharing of resources was the primary mode of exchange. For others, video (the Inquiry Learning Forum, Scheckler and Barab) or graphical representation (Investigating Physics, Rubin and Doubler) assumed a central role in promoting discourse.

In some cases, the use of tools is carefully scaffolded behind the scenes; the administrators design when a graphical representation will be introduced or when a video will be uploaded and shared. For others, the community is given a suite of tools to deploy as the need arises. For example, in the Inquiry Group (Bruce), constituents can choose from a toolbox of functionalities. Similarly, within working groups on MSPnet (Falk and Drayton), users can choose to utilize an interactive calendar, a threaded discussion, a file sharing tool, or a survey tool. New functionalities such as Web-video conferencing, whiteboards, and wikis soon will be incorporated into this suite of tools. This approach allows users to choose the tools with which they are comfortable and that best serve their purpose for communicating with different groups of people at different times.

Finally, the authors' understanding of the ways professional learning is actualized (strictly peer-to-peer, expert-to-novice, a mixture of expertise from different fields, or a combination of these), or the need to constrain the content or focus of exchanges, influenced the design for facilitation, moderation, and administrative functionalities. Thus, some communities (e.g., MERLOT, McMartin) encouraged wide participation, but made use of the customs of academic peer review, coordinated by a project core, to ensure quality control and to warrant the value of contributed content. MSPnet combined some centralized facilitation by project staff, but also fostered distributed leadership and facilitation among its many constituent groups, including small emergent communities that could be formed online by individuals, working parties, or others sharing work or topical interest.

3. How are community interactions influenced by size, coherence of membership, structure, and the presence of offline interactions? What are effective mechanisms to support a community, to sustain it, and to deepen members' interactions online?

The nature of an electronic community is a blend of vision and experience, of design and emergence. The way people can join it, inhabit it, and learn through it reflects important design decisions and has implications for the facilitation and "metabolism" of the organism: its internal and external processes of change and growth. For example, if an electronic community is an outgrowth of an offline community, this can ensure pre-existing patterns of collaboration, personal acquaintance, and at least some aspects of shared culture. For example, the virtual conference on sustainability (Falk, Lee, and Drayton) convened people who had shared in an online community (LSC-Net) for several years, but a significant number of the participants had also met one another face-to-face during preceding traditional conferences.

The criteria for participation also shape how the community will take form and evolve. Groups with restricted membership (the Investigating Physics course, Rubin and Doubler, or MSPnet, Falk and Drayton) have an easier time creating a sense of trust since their members know the relative size and composition of the group of people with whom they will be interacting. This "semiprotected" sense of community can foster frank exchange of resources, insights, and questions which are safest "backstage" (to use Goffman's term)—explorations of issues and dilemmas, strategies and methods (Goffman, 1959). This is more difficult to achieve in communities that are open.

www.mspnet.org — an electronic learning community for the Math and Science Partnership Program funded by the National Science Foundation

Another way in which these projects vary is in how homogeneous or heterogeneous the membership is with respect to professional backgrounds and purposes, scope of action, and typical collaborative patterns; the chapters in this book vary along this dimension as well. For example, if the site has multiple constituencies, the way its design reflects the relationships among the constituencies can play a significant role in nurturing the community, providing resources, and supporting its goals. If the membership is homogeneous as to professional focus (e.g., science teachers, as in the Inquiry Learning Forum, Scheckler and Barab) or interest (mathematics, as in the Math Forum, Shumar), the community structures can differentiate to support a range of interactions within an established practice or topic group. If, on the other hand, the membership is heterogeneous (as in MSPnet, Falk and Drayton, or the Inquiry Group, Bruce), then supporting communications within and between the nested communities is a key task for facilitators and will have structural implications as well.

Finally, structures and facilitation will shape and be shaped by the administrative structures and the leadership that emerges from within the community, and this dependency is explored in each of the chapters that follow. Some of these communities provide a range of pathways for members to participate and to contribute. MSPnet (Falk and Drayton) and the Inquiry Group (Bruce) enable leadership to emerge within several levels or areas of their communities, and leadership can range from contributing content to creating and facilitating small communities of interest or practice. MERLOT (McMartin) has a concentric structure from "patron" (resource user) to "core," which allows members to move from peripheral to central roles in the identification and peer reviewing of materials on the site.

4. How does one assess the success of such an effort over time?

A consideration of measures of success for these communities leads directly back to the goals and vision underlying each one. It is interesting to note that none of these projects makes a case for its value on the basis of "numbers served," but all take for granted that active participation is necessary evidence of value, or at least usefulness. The narratives present a variety of measures beyond this, which reflect the role of exploratory, research-driven projects, even if a service or product is an ultimate goal. Concretely, by its very nature, a Web-based project preserves some of the story of its community and the resources it has accumulated, making them available for the next generation of investigators and users.

The kinds of participation that emerge during the project's development are another outcome, harder to measure, but with a definite impact on the capacity of the participants to carry forward their work. The growth of expertise, the density of interconnecting ties, the greater experience with new collaborators—all these are presented as returns on investment, different forms of enrichment of the professional development community. Continued use of the tools developed, the connections made, and the ideas tested and propagated is additional evidence that in fact professional learning has occurred and has been integrated into the practice of the participants. Change in participant quality is as important to measure as number of participants; neither is reducible to the other's terms.

Given the breadth of types of communities and forms of professional development represented, the readers of this book might naturally find themselves asking which method is best: constrained or open content; online course or community forum; an intimate or broad and open community? We can save you the suspense—there is no one right answer. Yet, each of the authors provides some reflection on this question, and it is our hope that the way they thought about and measured the success of their venture will inform others who are in the process of creating and joining a professional learning community.

REFERENCES

Goffman, E. (1959). *The presentation of self in everyday life.* New York: Anchor Books.

Joni K. Falk *and* ***Brian Drayton*** *are co-directors of the Center for School Reform at TERC. joni_falk@terc.edu, brian_drayton@terc.edu.*

Creating and Sustaining Online Professional Learning Communities

Edited by Joni K. Falk and Brian Drayton

"[This volume] explores the varied, conflicting, productive, and unexpected ways that online communities can contribute to teacher professional development and offers concrete solutions."
—From the Foreword by Marcia C. Linn, University of California, Berkeley

The book is divided into two parts. Part I comprises chapters on long-running electronic communities that have a broad, growing membership base. The members have a large role in shaping the professional learning that takes place. The chapters in Part II describe professional development experiences that are more targeted and constrained. They engage smaller populations for a more well-defined period (e.g., a semester, a 10-day conference) in activities such as sharing classroom practices, engaging in an online course, or participating in a virtual conference.

Part I

MSPnet: Design Dimensions for Nested Learning Communities by Joni K. Falk and Brian Drayton

Building an Airplane in the Air: The Life of the Inquiry Group by Bertram C. Bruce

Communities, Texts, and Consciousness: The Practice of Participation at the Math Forum by Wesley Shumar

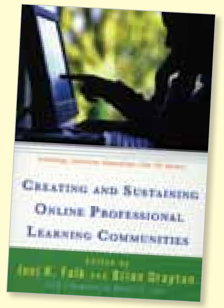
MERLOT: A Community-Driven Digital Library by Flora McMartin

Part II

Designing for Inquiry as a Social Practice by Rebecca K. Scheckler and Sasha A. Barab

The Role of Representations in Shaping a Community of Scientific Inquiry Online by Andee Rubin and Susan J. Doubler

Structuring a Virtual Conference to Facilitate Collaboration and Reflective Dialogue by Joni K. Falk, Soo-Young Lee, and Brian Drayton



Available from Teachers College Press, www.tcpress.com, 1.800.575.6566

feature

Windows on Earth

By Peggy Kapisovsky

If you are old enough, as I am, to remember the landing of the first man on the moon, then you can recall the palpable excitement on that fateful July day more than forty years ago. Eyes were glued to TV screens (albeit small black-and-white ones); breaths were held.

Through the years, space flight has become less of a media event, still there is something about the beauty and awe of space that continues to intrigue and inspire people. Probe a little and you'll discover much to marvel at. You will find, in fact, how many people yearn to fly in space. Start with Richard Garriott.

Richard spent ten days in space in October 2008 as a citizen astronaut. He was the sixth client of a company called Space Adventures, which, for a fee, will train, equip,

Taking photos from the window of the International Space Station

and arrange for private citizens to experience the wonders of space travel. Not only is Richard an adventurer, explorer, and video game pioneer, he is the son of Owen Garriott, an astronaut who flew two space missions, in 1973 and 1983. When Richard launched in the Russian *Soyuz* spacecraft on October 12, 2008, to fly to the International Space Station, he became the 1st second-generation space traveler from the United States.

Few of us will get the chance to experience space travel, but something Richard took with him offers all of us the possibility of viewing Earth from space, of gazing out at the world in all its beauty. He carried a software tool that simulates the views that astronauts see from the International Space Station.

You might ask why astronauts need simulation software when they see the real thing. Astronauts take photos. They have taken hundreds of thousands of images over the years for scientists and educators, not to mention photos for themselves as tourists in space. Imagine moving at a speed of 17,210 miles per hour about 250 miles above Earth. Imagine also that there are no signs informing you that you are now crossing the border of Turkey or Kenya. How do you know what you are seeing and when to snap the shutter? Therein lies the challenge.

The software, Windows on Earth, is a state-of-the-art digital system that simulates views from the International Space Station and identifies target areas to be photographed. Look down at the Mississippi River delta's silt flowing into the Gulf of Mexico or the Klyuchevskaya erupting volcano spreading ash into the atmosphere.

Left: Window on Earth interactive website; Top right: Owen Garriott; Bottom right: Richard Garriott

The software even sends out alerts as to what sites are approaching in the next ten minutes. Mounted next to the window on the International Space Station, the software can assist astronauts in pinpointing targeted sites to photograph.

Windows on Earth is unusual: it was designed as an educational tool and was adapted for astronaut use because of its very realistic simulation of Earth as seen from space. Typically, scientific tools are first developed for professional use and then adapted for educational and public purposes.

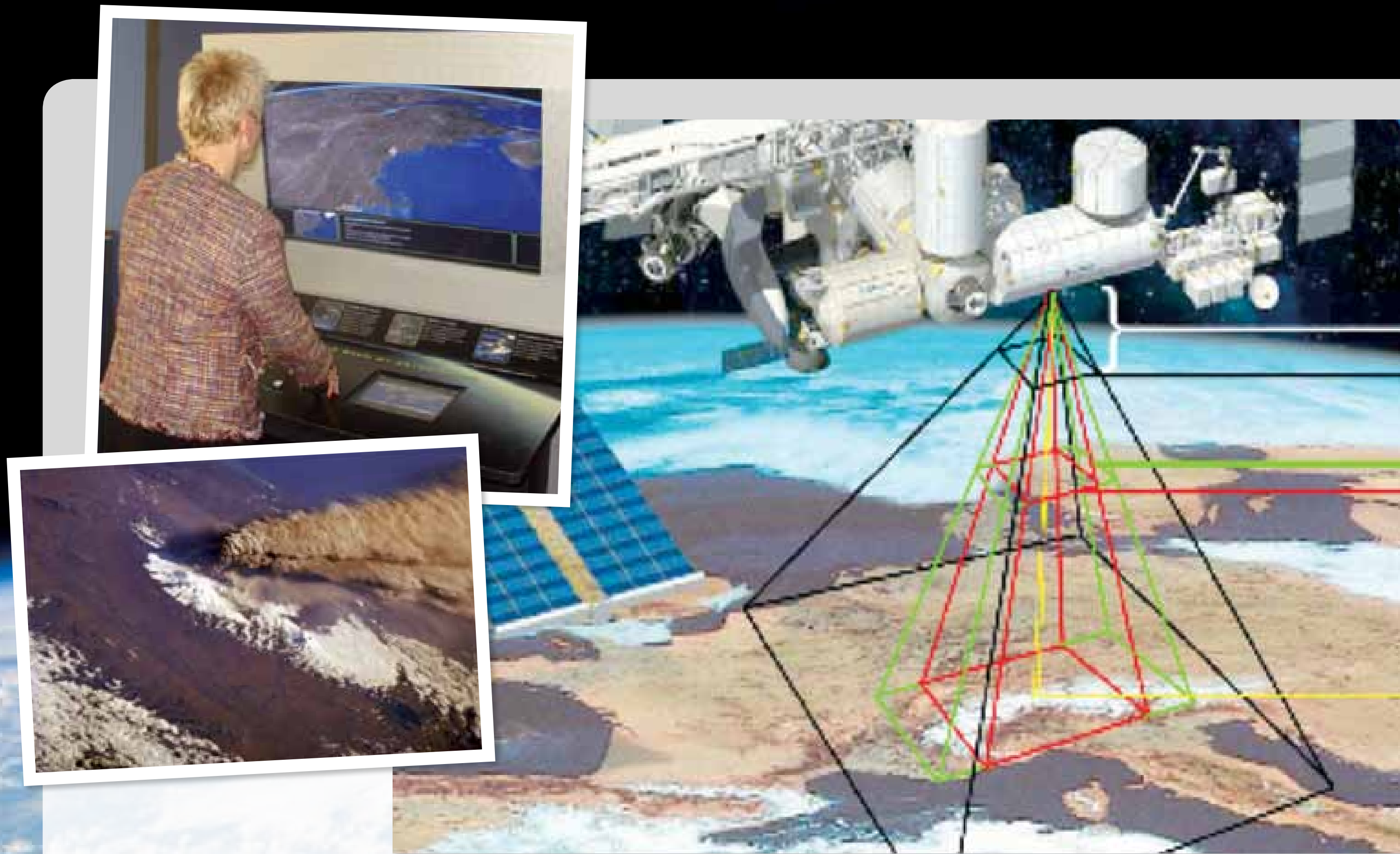
With funding from the national science foundation, TERC conceived and developed Windows on Earth as a website and museum exhibit that allows people to experience vicariously the panoramic views from the International Space Station as it circles the Earth every 91 minutes.

"Windows on Earth lets you experience the world as if you were an astronaut. You can look back and see the beauty of Earth. Viewing Earth from space offers ethereal and evocative images that help you think about our world in new ways," marvels Dan Barstow, who directed the Windows on Earth project. He is now president of the Challenger Center for Space Science Education and a proponent of state and national policy reform in Earth and space science education.

Windows on Earth visitors see the Earth in high-resolution, photo-realistic color and 3D. They can explore where they wish, follow the orbit of the International Space Station, select targets to "photograph," alternate between day and night, and peer over cloud cover. The system was designed to make the experience as realistic and interactive as possible.

Not surprisingly, a complex undertaking such as creating realistic simulation software requires several partners. TERC's key partner was the Association of Space Explorers (ASE), an organization of individuals who have flown in space. ASE soon recognized the potential of the software for use by real astronauts as well as by virtual ones. So Owen Garriott and his son, Richard, who was soon to venture into space, came aboard. Richard would test the software tool on the International Space Station.

Richard conducted several scientific experiments during the ten days he was in space and took thousands of photos, including many of the same sites that his father, Owen, had photographed when aboard Skylab II in 1973. Using Windows on Earth mounted next to his viewing window, Richard knew when he was approaching specific targets. If clouds covered the area, the visualization software was especially helpful. Richard credits the simulation software for assisting him to pinpoint chosen targets.



Top left: Windows on Earth museum kiosk; Bottom left: Image of Klyuchevskaya volcano, Russia; Right: Windows on Earth uses state-of-the-art visualization technology

If you want to experience the joy of viewing Earth from space, you can head to one of several museums that have installed the Windows on Earth exhibit, including the National Air and Space Museum; St. Louis Science Center; Museum of Science, Boston; Montshire Museum of Science; Connecticut Science Center; and the Kenai Alaska Challenger Learning Center. You can also simply use your computer to connect to winearth.terc.edu for the pleasure of following the orbit of the International Space Station and seeing what the astronauts see as they peer out at the world.

One final bit of space lore: When Richard Garriott returned from the International Space Station, he flew with the 1st second-generation Russian cosmonaut, Sergei Volkov. Space travel had moved into the second generation, and tools for all of us to travel vicariously are doing the same.

Peggy Kapisovsky is a researcher and freelance writer.

Windows on Earth was funded in part by the National Science Foundation DRL-0515528. Other funders and partners include the Association of Space Explorers, Geofusion, WorldSat, Challenger Learning Center, and NASA Johnson Space Center

Windows on Earth

Take your seat on the International Space Station and have your own "Window on Earth."

Explore Earth as astronauts see it.

winearth.terc.edu

feature

BioTeach

By Polly Hubbard

On a hazy July day, 55 casually dressed science teachers from public high schools across Massachusetts gather in the air-conditioned comfort of Framingham State College. Excitement is in the air as the teachers begin to use expensive, specialized equipment for practicing procedures used in forensics, molecular biology, genetics, microbiology and biochemistry. Goggled eyes focused on their lab benches, the teachers practice how to measure and transport a precise volume of liquid by using a micro-pipette; in a second room they work with partners to interpret bands of DNA that have separated and migrated across a clear gel in response to an electric charge.

The teachers' enthusiasm stems not only from the stipends, points towards recertification requirements, college-level textbooks, and lab manuals that they receive, but most of all from the hope that the training will help them do more science labs with their students.

In this case, the science relates to biotechnology, a rapidly growing industry contributing to advances in medicine, energy, the environment, and many other fields. Science classrooms in the 21st century need to introduce students to the procedures and applications of biotechnology. For this to happen, teachers themselves must gain some biotech experience—which is precisely what the teachers at Framingham are doing.

The teachers are participating in BioTeach, an ambitious statewide teacher professional development program designed to support biotechnology instruction and career awareness activities in all Massachusetts high schools. BioTeach, a multiyear program, provides teachers with equipment, supplies, and training in procedures and career awareness that they can use in their high school science classrooms. A major component of the program is the introduction to three different laboratory experiences that teachers can share with their students. The program aims to inspire scientific curiosity, increase student participation in science, and expose students and teachers to science careers.

Program Need

BioTeach is run by the nonprofit Massachusetts Biotechnology Education Foundation, whose offices overlook the pharmaceutical development labs that make up the bulk of the biotech industry in Massachusetts. A major concern for the industry is that too few high school students are attracted to post-secondary majors and careers in science, technology, engineering, and math (STEM). The STEM workforce shortage is deemed a serious challenge that has penetrated public and opinion-makers' consciousness—and government divisions such as the National Institutes of Health, the National Science Foundation, and the U.S. Department of Education have been leading the federal effort to strengthen the STEM workforce pipeline. BioTeach, funded with a combination of public (U.S. Department of Labor) and private (biotechnology company donations) money, aims to make a difference for students and the life science industries.

The Role of Evaluation

In 2005, BioTeach asked TERC to evaluate their program. TERC's evaluation team has targeted data collection to help program managers implement the training more consistently and learn to use data to make choices and changes in the scope and direction of the program.

482 teachers from more than 150 Massachusetts schools attended BioTeach summer workshops from 2005–2008.

The BioTeach Mission:

- Enable every public high school in Massachusetts to teach biotechnology methods in its biology classrooms.
- Engage high school students with hands-on lab experiences that inspire scientific curiosity, understanding and for some, a career in the life sciences.

Learn more at www.massbioed.org

Evaluation is sometimes viewed as a reporting activity that results in a summary document. Often the report has little impact on program design or improvement. TERC's Evaluation Group sees their role differently, and designs evaluations that inform program development.

"It has been wonderful to see BioTeach move from an organization with one good idea—provide equipment to make hands-on experiences possible—to an organization that has many," says Karen Mutch-Jones who is responsible for overseeing evaluation research design. The program now provides classroom kits to make new labs more accessible, expert mentoring in a self-contained classroom on wheels at each school, and college-level training in the science behind the techniques.

According to Mutch-Jones, "Small organizations like this one can burn out as the program grows beyond their capacity to manage it. What works for 30 schools can be impossible to implement with 150 schools. BioTeach staff have done a good job using evaluation data to respond to changing needs. They have used the data to make their jobs more manageable."

When TERC began evaluating BioTeach, the program allowed any science teacher from a participating school to attend the trainings, no matter what course they taught. After reviewing survey responses and applicant data about their teaching assignments, it became clear that many teachers were unlikely to apply their training because the content best aligned with biology class work in genetics, and the labs fit the needs of biology teachers more easily than chemistry. Once that was made clear at application time, schools were better able to send the right teachers to the trainings, and the sessions became easier to run because the audience was less heterogeneous. Student lab use increased in the years following this change.

Teachers and program developers alike initially expected that all they had to do was learn the steps of the lab and that would lead to classrooms awash in enthusiasm for biotechnology. However, evaluation data from focus groups showed that teachers had many challenges within the school environment that could not be solved by just getting lab equipment and manuals. They had large classes of 30 or more students, lunch blocks interrupting lab classes, rooms without running water, or students allergic to lab materials. Evaluators helped BioTeach staff understand the challenges teachers were reporting and why they could be serious obstacles to meeting program goals. Working with evaluators, BioTeach staff selected those areas they could address with programmatic responses. They developed ways to divide the labs into manageable chunks for shorter class periods and carved out time to review teaching tips for large classes. This included time to troubleshoot facilities issues and find alternate materials to illustrate the same concept without sending a student to the emergency room. They also found ways to integrate new investigations. With their small staff, BioTeach cannot be expected to address every hurdle to implementing new curricula, but they tackled priorities that seemed to inhibit overworked teachers from attempting solutions themselves.

BioTeach teachers report that the program clearly has an impact on students — their interest in and awareness of biotechnology, as well as their learning of science and their understanding of real-world uses of science.

Changes to Training

Many changes spurred by evaluation have also been made to the initial intensive three-day training. The developers have moved away from a focus on the techniques associated with lab procedures, which dominated the first year of the program, towards a focus on science learning—what do the results mean? what questions can the procedure address? how can the knowledge impact daily life?

"We have changed things in a million ways because of the relationship with TERC evaluators," says Robert Ross, BioTeach program director. "It has altered not only what we do but why we do it. It has taken our program to a deeper and more meaningful level for the teachers we work with. They have helped us see the need for different learning components and organizational features to help us manage the program better. We can see our improvements as data from more recent cohorts shows growth and increasingly positive results. When I began managing BioTeach, I found that my conversations with the evaluators along with their documents really helped me with understanding the focus and goals of the program."

Moving Forward

As BioTeach developed and evolved, the role of the evaluation team changed as well. No longer does the program staff view the evaluators with apprehension, accepting them as necessary for filing reports to the Department of Labor and not much else. Now the team is a desired partner, asked to consult and brainstorm at the beginning of new strands of work. BioTeach staff are eager to pilot new ideas, get findings, and debate the merit and value of the team's observations. Mutch-Jones reflects, "We feel like we are an integral part of the project team, enhancing the program design. It is a satisfying place to be."

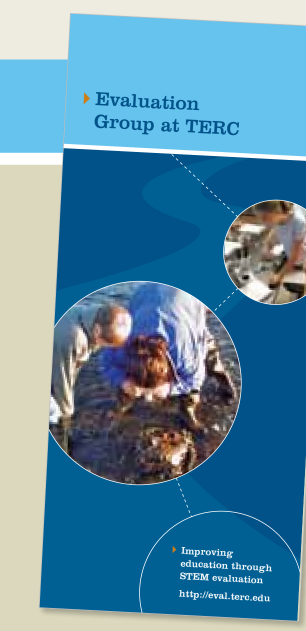
Polly Hubbard, Karen Mutch-Jones, *and* ***James Hammerman*** *are co-leaders of TERC's Evaluation Group and BioTeach evaluators. polly_hubbard@terc.edu.*

Evaluation Group at TERC…

Provides evaluation research and consulting that ranges from close observations of single events to large-scale multiyear initiatives. Evaluators are also experienced researchers, teachers, curriculum developers, and teacher educators.

Projects include:

- Professional development and teacher education programs
- Curricular materials
- Online courses
- Assessment systems
- PreK-university level programs
- Diversity and equity initiatives
- Afterschool programs
- Adult basic education initiatives
- Museum exhibits and other informal education opportunities



For more information contact evaluation@terc.edu or visit eval.terc.edu

feature

RENEWAL Through Lesson Study

By Sarah Ahearn

Early morning one hot summer day, I climbed into a car with three of my colleagues from school to begin the drive into Boston. We all had committed to attending a four-day professional development institute as part of our participation in a year-long research project funded by the National Science Foundation—Lesson Study for Accessible Science (see sidebar, page 20). I wasn't quite sure why I agreed to join this effort. Perhaps it was my inability to say "no" when offered the opportunity to learn more about teaching and science. Admittedly after several years in the classroom, I did wonder whether this experience would have any affect on my teaching. I didn't know then how my decision to join my colleagues on that hot summer day would take me on a journey that would renew my passion for teaching science.

I felt comfortably settled in my career as I began this journey. I had been teaching middle school science for seven years. I attended cutting-edge classes in college, received a master's degree in educational technology, earned a license in administration, and spent hours attending a variety of classes and professional development workshops. I could draw on a diversity of experiences and knowledge in teaching science, and therefore, I considered myself to be on top of my game! Looking back, I realize that my thinking had narrowed, and my teaching was becoming routine—something I never imagined would happen to me.

My students came into class, followed my prescribed programs, completed my "tried and true" assignments, and as a result seemed to learn science. I had proof in my assessments, so I settled into a uniformity of days where the excitement I once felt about the science curriculum and my instruction waned.

"Yes, that is a good diagram," I would compliment a student, but I wouldn't really look closely at what his drawing told me about his learning. I would review a stack of students' completed assignments, sometimes wondering if the students found them beneficial. I'd quickly let my gnawing uncertainty go, convincing myself that I had created good lessons, and it was important to keep pace and move on to the next thing on my "to do" list. I used the same techniques that I considered foolproof and therefore found no need to seek new ones. I would try out the new ideas I learned at professional development meetings, but at the end of the year, I would find evidence of them in the bottom of a drawer. Nothing that I heard at these meetings really enlightened me. I was never forced to analyze material or students' responses to the point that the process became a part of my regular practice. I am surprised that I wasn't more analytical and that I had lost my inclination to question—the very essence of the subject I taught. In retrospect, I really wasn't a bad teacher—I had just become stale and complacent.

The Lesson Study for Accessible Science (LSAS) Experience

My colleagues (two middle school science teachers and a special education teacher) walked into the summer institute not knowing much about the Lesson Study process. We spent four days learning about this professional development approach that originated in Japan. We viewed Lesson Study teams videotaped in Japan, reflected on the innovation, and reviewed Lesson Study documents designed to guide us through the year-long implementation. We worked through all of the steps in a Lesson Study cycle, stressing the importance of anticipating student responses to instruction at key points in a lesson and observing and documenting actual student responses when the lesson was taught. To practice, one LSAS team taught a lesson to a group of students, grades 4–7, while all other participants observed. Everybody then debriefed the lesson. We also learned about what it means to create special education accommodations in the science classroom.

While it was not totally clear how this new knowledge would affect our teaching, it was clear that through our concentrated study, the four of us had formed a strong bond. It truly is a great experience to work with enthusiastic colleagues in the field of science education. I am grateful that we had the four days of concentrated work in the summer, as it would have been hard to form such a bond during the academic year.

Cycle 1

When we returned to school, we entered our first real lesson study cycle with a great deal of desire and determination. We got together on the weekends and we met after school. We spent hours pouring over our "best tricks" aimed at creating the most perfectly accommodated lesson; we did not want to let each other (or ourselves!) down. Together, we created graphic organizers and broke down text into chunks so that learning-disabled students could comprehend the information. We used a picture book as a "hook" to activate students' prior knowledge, designed specific manipulatives so that students could move pieces when categorizing, carefully created student work groups, placed vocabulary words on charts so that students would focus on the ideas and not on the spelling of key vocabulary, and made sure we had frequent check-ins with struggling students.

We generated a lot of accommodations and they were all very artfully presented. There was a tremendous amount of laminated glitz packed into one grand lesson designed to increase knowledge of the scientific method. Once we reconnected with our creativity and our passion for science and teaching, we couldn't stop. Of course, we also exhausted ourselves.

While debriefing after teaching the lesson, we took a breath and thought again about the purpose of Lesson Study. It was to help us understand student thinking and, based on such an analysis, to craft lessons that helped everyone to meet the lesson learning goals. We began discussing individual students for the first time, then simplified a few aspects of the lesson and taught it again. This time it was more focused.

Lesson Study is about a team focusing on some aspect of teaching and then analyzing it; it is not about creating a grand lesson. We had to experience this to really understand just how focused the process should be. Perhaps as a result of our exhaustion and our learning, I began to see things differently—could progress actually be made by thinking "smart and simple"?

Cycle 2

In the spring, we began the second Lesson Study cycle. This time, as each of us sat down at the table, we looked at each other with anticipation—would we once again set out to create another grand lesson? There was a collective sigh of relief when we agreed upon a lesson that focused on the

Lesson Study for Accessible Science Model

Summer Institute

- Develop initial relationship and explore collaborative processes with team members
- Experience the steps of Lesson Study and become familiar with Lesson Study forms and documents
- Analyze types of accommodations and take initial steps toward creating them
- Develop classroom observation tools

School-Year Lesson Study Cycles (2)

- Discuss unit goals and determine specific lesson goals for students with learning disabilities
- Review curriculum and explore science content and processes related to study lessons
- Collaborate in designing and teaching lessons with accommodations
- Carefully observe and collect data on student learning in relation to specific classroom practices/accommodations during the study lessons
- Revise and reteach the study lessons
- Debrief and reflect on study lessons and accommodations specifically

Lesson Study for Accessible Science

Researchers from TERC and the Education Development Center studied the impact of Lesson Study on general and special educators in inclusive classrooms. A modified Lesson Study professional development model was used to support the collaboration of science teachers and special educators as they created accommodations to make science accessible to their students with learning disabilities. Project research focused on the development of teacher knowledge of science and learning disabilities, the development of science-specific accommodations, and changes in classroom practice during the Lesson Study intervention.

individual needs of the learning-disabled students in our classes. The accommodations we created needed to support reading and comprehension within the science investigation. Therefore, after careful analysis of the students and what we learned about accommodations during our first cycle, we created a graphic organizer to help students chunk the information into smaller, more manageable segments as they worked through the lab. From the first cycle, we learned that these accommodations were the most effective.

Our entire approach to planning the lesson changed in this second round. We spent much less time creating materials. Instead we analyzed the needs of the specific learners involved. In a way, we were actually scientists, questioning and analyzing what we knew about each student rather than generalizing about the category we placed them in. The focus was taken off ourselves, and how good we could be as teachers, and was placed where it belonged—on the needs of the learners. It all seemed too simple, and so there was a level of anxiety as we walked into the classroom the day of the lesson. Fortunately, that anxiety dissipated as the lesson unfolded and we saw the students engaging in the activity, staying on task, and participating in the small group discussions. We left the classroom with a strong sense of accomplishment and a greater understanding of our students.

There is a difference between working intelligently and working hard. Some people work hard and make little progress. They focus on too much or not enough. They become entrenched in patterns that lead them in circles. Other people work intelligently and pave the way for progress. They focus on what needs to be studied and then they conduct research, analyze the results, and make positive adjustments. In the beginning our team worked hard making too many accommodations. In the end, we discovered that a more scientific approach—one that is fostered by the lesson study process—produced the greatest results. We even inadvertently discovered that making simple changes to existing structures can change teaching in profound ways for all students, not just for our targeted learning-disabled students. This was not something we set out to discover; instead it was a pleasant surprise that emerged from our work. That is often the essence and result of Lesson Study discoveries.

Reflections and Renewal

At different points in this experience, I gradually began to feel more secure in what I did not know. The fear of not knowing is a common bond we all share as educators. The reality is that we will never know everything, especially in this era of information overload. Through Lesson Study, however, we can learn and share what we need to know together as professionals. In talking extensively about teaching with colleagues and by observing their classrooms, I learned so much: I learned more about my students by watching others teach theirs; I learned how to tweak my teaching to make it more effective and efficient; I learned how to meet the needs of more students; and I became fully aware of the ways in which I was preventing myself from learning. By the end of this experience, my enthusiasm for the profession and my humor and curiosity had returned. I was once again appreciating the joys and challenges of teaching science.

*LSAS was funded by the National Science Foundation (DRL-0455710). Project staff: **Karen Mutch-Jones**, **Gilly Puttick** and **Daphne Minner** (Principal Investigators); **Polly Hubbard**, and **Marjorie Woodwell**.*

***Sarah Ahearn** is a middle school science teacher and a participant in the Lesson Study for Accessible Science project.*

FURTHER READING

To learn more about the steps of the lesson study process, see *Lesson Study: A Handbook of Teacher-Led Instructional Change* by Catherine Lewis (2002), Research for Better Schools.

To learn more about how lesson study can provide pathways to instructional improvement and ways in which descriptive research is needed to more fully understand the innovation, see "A Deeper Look at Lesson Study" by Catherine Lewis, Rebecca Perry, and Jacqueline Hurd in *Educational Leadership*, February 2004 and "How Should Research Contribute to Instructional Improvement? The Case of Lesson Study" by Catherine Lewis, Rebecca Perry, and Aki Murata in *Educational Researcher*, April 2006.

New Projects

Rethinking How to Teach Energy Project at TERC

Biocomplexity-Transforming Innovative High School Curriculum

This project is developing a multimedia-enhanced version of the TERC-developed Biocomplexity and the Habitable Planet (DRL-0628171) curriculum, a high school capstone science course. The Biocomplexity developers are designing additional UDL-aligned scaffolding to help more teachers use the material in heterogeneous high school science classrooms. The Biocomplexity and the Habitable Planet curriculum consists of innovative, inquiry-based instructional materials to engage high school students in the recent science of coupled natural and human (CNH) systems.

Partners: CAST
Funder: National Science Foundation, DRK-12 (DRL-1020089)

Contribution of Science Fair to Middle School Student Interest in Science Careers

This exploratory study will examine the effects of participation in Science Fair—a voluntary scientific investigation program available to middle and high school students—on students' interest in, self-efficacy, and future plans in science. It employs a quasi-experimental design in which students who participate in Science Fair activities, are compared with those who do not. This study will examine middle school students': 1) interest in science topics; 2) interest in science careers; 3) reported feelings of self-efficacy; and 4) plans to pursue additional courses pre- and post-Science Fair. A report will be used to identify issues to explore in future work.

Funder: The Noyce Foundation

Confronting the Challenges of Climate Literacy

This project is designing, developing, and testing a climate science curriculum and professional development model for high school students and their teachers. Project researchers will study and evaluate primary challenges to student understanding of change on multiple and embedded temporal scales and how to overcome those challenges. The project staff will create capstone materials, which will contribute to a collection of modules that will eventually allow teachers to teach various kinds of Earth and space science courses at the high school capstone level. These courses might include—for example—material on climate science and climate change, environmental science, Earth system science, weather, and geology.

Funder: National Science Foundation (DRL-1019721)
Collaborative Partners: Mississippi State University, University of Texas-Austin Institute of Geophysics
Other Partners: Michigan State University Teachers and schools in Texas and Mississippi, SERC, Carleton College: CIRES, University of Colorado-Boulder

Creating a Web Presence for the I3 Track

This two-year project is researching, designing, and facilitating a web presence for the National Science Foundation's "Innovation through Instructional Integration" (I3) program—a track instituted in 2008 to challenge United States higher education institutions to strategically integrate NSF awards into programming to address the scientific, educational, and technological challenges currently facing our society. Building on the collective experience of the project team in researching, initiating, and managing electronic communities of practice, the I3 site will be designed around extensive user research and collegial design principles. The proposed website will make the I3 track more transparent to stakeholders and the public to improve visibility of the I3 projects and effectively disseminate project solicitations, research, and achievements—unifying the internal online community of users through a manageable and organized design hierarchy to optimize opportunities to share resources, highlights, research, and related project work across the various program locales.

Funder: National Science Foundation (DUE-1027418)

Evaluating DMI

Evaluating the Developing Mathematical Ideas (DMI) Teacher Professional Development Program is a 3.5 year efficacy study of a well-known, commercially available math teacher professional development (PD) curriculum. The study uses experimental and quasi-experimental methods to ask: How does elementary teacher participation in DMI affect teacher knowledge, teaching practice, and student learning?

The project works with about 195 public school teachers and their students in several urban and suburban school districts in Massachusetts. Volunteer teachers are randomly assigned either to PD with DMI in the first year of the efficacy study, or as a control/comparison group who will wait till the second year of the study to receive DMI PD. Both groups of teachers will be followed through two academic years, gathering evidence about teacher knowledge, teaching practice, and student achievement. There are multiple measures of each construct, including video analyses of teacher practice, and a new video-based measure of teacher knowledge. Analyses use OLS regression, hierarchical modeling, and structural equation modeling, as appropriate, to compare the two groups and to track changes over time.

Funder: National Science Foundation, DRK-12 (DRL-1019769)

The Handheld Signing Math & Science Dictionaries for Deaf or Hard of Hearing Museum Visitors Research Project

TERC and the Museum of Science, Boston (MoS), are studying the integration—into MoS's Take a Closer Look and Science in the Park exhibits—of iPod Touch versions of the Signing Science Pictionary (SSP), Signing Science Dictionary (SSD), and the Signing Math Dictionary (SMD). Project partners are adding human voice to all the text-based components, developing a Flash-based movie for each dictionary to introduce its features and an accompanying activity to practice its use, and researching how two audiences, each of which includes museum visitors who are deaf or hard of hearing and whose first language is sign, use the dictionaries to access science content during visits to the exhibits. One audience is family visitors, ages 5–12+; the other audience is classroom visitors in grades K–8+. The partners will also begin to establish the kinds of learning gains that are possible. The dictionaries were originally web-based an intended for use in classrooms. They were developed by TERC and Vcom3D (innovators of the SigningAvatar® technology that powers the dictionaries) with funding from NEC Foundation of America, the National Science Foundation (HRD-0533057), and the U.S. Department of Education (H327A060026) for the SSD; the National Science Foundation (HRD-0833969) for the SMD; and the Carl and Ruth Shapiro Family Foundation, Disability Inclusion Initiative and the U.S. Department of Education (H327A080040) for the SSP.

Partners: Vcom3D, Museum of Science, Boston
Funder: National Science Foundation, ISE (DRL-1008546)

INK-12: Teaching and Learning Using Interactive Inscriptions in K–12

This project is investigating how the combination of pen-based computing and wireless communication can support and transform classroom practices that are known to enhance student learning in STEM disciplines. This work builds on the NSF-funded exploratory study INK-12: Interactive Ink Inscriptions in K-12 (NSF Collaborative DRL-0822278 and DRL-0822055) that examined the role that pen-based wireless computing could have in 4th and 8th grade science and math classrooms.

Project researchers will work in three Massachusetts districts to study additional classrooms using pen-based wireless computing and create a research-based software design for a pen-based wireless technology that can support students' math and science learning. The design will then go through an implementation and evaluation cycle. This project will build a website for dissemination purposes through which research reports and downloadable versions of the software will be available.

Funder: National Science Foundation, DRK-12 (DRL-1019841)

Mixing in Math SMILE Database

Mixing in Math is developing a set of digital materials for inclusion in the SMILE Pathway database—an online collection of free activities useful for integrating math and science into elementary children's routines in school and beyond. The SMILE Pathway is a partnership between the Lawrence Hall of Science, The Exploratorium, The New York Hall of Science, The Science Museum of Minnesota, The Children's Museum of Houston, ASTC, and NSDL.

Funder: National Science Foundation, NSDL, through the Regents at the University of California (DUE-0735007)

Perceived Impact of Science Fair Participation on Scientists' and Engineers' Interest in Science

This study will examine the effect of Massachusetts Science Fair experiences on a proposed sample of scientists and engineers who hold degrees in the natural sciences. The 25 respondents will be culled from across the scientific research sector in Massachusetts and interviewed about 1) their experience in Science Fair and/or independent scientific research in secondary school and 2) the degree to which these experiences informed their choice of careers. The resulting report will be submitted to policy makers, highlighting the perceived impact of Science Fair participation on working science professionals.

Funder: The Noyce Foundation

The Poincaré Institute for Mathematics Education

In this partnership led by Tufts University's departments of Mathematics, Physics and Astronomy, and Education, TERC is joining nine diverse partner school districts in Massachusetts (Fitchburg, Leominster, Medway, Medford, and Somerville); New Hampshire (Dover, Sanborn, and Timberlane); and Maine (Portland) to

http://mixinginmath.terc.edu/

improve the teaching and learning of mathematics in middle school and build stronger connections between the elementary, middle, and high school math curricula. This project seeks to broaden teachers' understanding of mathematics and of mathematics education, focusing on how middle school children think and learn to identify, streamline, and re-envision how they teach critical math and physics topics to reach all students. The impact of the project will be evaluated by the multidisciplinary research team.

Partners: Tufts University, 9 districts in Massachusetts, New Hampshire, and Maine.
Funder: National Science Foundation, MSP through Tufts University (DUE-0962863)

A Practice-Based Approach to Professional Development in Science in K–5 Classrooms

The Chèche Konnen Center at TERC is collaborating with the Boston Teacher Residency of the Boston Public Schools to design, develop, and study a practice-based inquiry approach to professional development that prepares new teachers to move K–5 science teaching toward more rigorous, engaged, and equitable learning for their students. The innovation to be investigated will be centered in a school-based seminar designed to introduce new teachers to practice-based inquiry—investigations into everyday practice—as a form of professional learning.

Partners: The Boston Teacher Residency of the Boston Public Schools
Funder: Department of Education, IES

Rethinking How to Teach Energy: Laying the Foundations in Elementary School

Responding to a need for a coherent pedagogical approach to teaching energy and matter, this exploratory project is researching and developing a proposed grade 3–5 learning progression that provides a strong base for understanding energy in middle school. Project researchers will identify core concepts that will develop across multiple grades and structure the learning progression; interview children to identify precursors to the core concepts, as well obstacles to learning them; work with teachers to conduct "teaching interviews" in urban after-school settings to explore key learning experiences that would allow students' understanding of core ideas to progress; and design and disseminate the progression and blueprint with suggestions to extend the material to a complete K–12 energy learning progression.

Funder: National Science Foundation, DRK-12 (DRL-1020013)

Signing Math Pictionary for K–4 Learners Who Are Deaf or Hard of Hearing

TERC and Vcom3D are using the SigningAvatar® assistive technology to create an illustrated interactive 3D dictionary of signed mathematics terms for children in grades K–4 who are deaf or hard of hearing. They will evaluate it for usability and feasibility and add to the Avatar lexicon of signs for mathematics terms for use in developing other mathematics materials. This project builds on research that led to the development of the Signing Science Dictionary (SSD)—a dictionary of ~1,300 science terms and definitions for grades 4–8—and the Signing Math Dictionary for grades 5–8.*

Partners: VCom3D
Funder: Department of Education, Steppingstones (H327A100074)

Signing High School Science

TERC and Vcom3D are producing a unique set of learning tools that will increase access of high school students who are deaf or hard of hearing to educational content in life and physical science. During this four-year project, the partners will use the SigningAvatar® assistive technology to research and develop two illustrated interactive 3D dictionaries for grades 9–12: a Signing Life Science Dictionary (SLSD) and a Signing Physical Science Dictionary (SPSD). The partners will evaluate the extent to which use of the SLSD and SPSD increases understanding of standards-based content in the life and physical sciences, promotes command of the languages of life and physical science, and furthers the ability to study these content areas independently. The project will build a robust avatar lexicon of signed life and physical science terms that developers, educators, and professionals can use when generating signed life and physical science materials. The SLSD and SPSD will be disseminated on CD-ROM and through Web-based versions. This project builds on research that led to the development of the Signing Science Dictionary (SSD)—a dictionary of ~1,300 science terms and definitions for grades 4–8—and the Signing Earth Science Dictionary for grades 9–12.*

Partner: Vcom3D
Funder: National Science Foundation (DRL-1019542)

Targeted Research for a Serious Games NSDL Pathway

EdGE@TERC has been awarded a targeted-research grant from ISE/NSDL to study the feasibility of creating a serious-games pathway for digital STEM resources. EdGE (the Educational Gaming Environments group) will design and run a prototype trans-media game that uses mobile handhelds with augmented reality, Web-based social networking, and massively-multiplayer online environments to create a community of citizen scientists asking "What about Bubba?" In the game, Bubba is a white gannet that nests in Cape St. Mary's, Newfoundland. When he arrives at his regular feeding spot in the Gulf of Mexico in January 2011, he does not like what he sees. Food is scarce, and he needs help to figure out what to do. The citizen scientists (serious gamers) will work together to monitor, analyze, and interpret coastal conditions, bird migration, and other environmental indicators of healthy bird populations to help Bubba and his feathered friends get what they need to survive and prosper. While creating and studying the game, EdGE will document the challenges and opportunities for STEM learning presented in using digital scientific resources in the context of serious games.

Partners: Virtual Space Entertainment, Institute for Learning Innovation (ILI)

Funder: National Science Foundation, NSDL (DUE-1043357)

Using Routines as an Instructional Tool for Developing Students' Conceptions of "Proof"

This project is developing and investigating a teaching model to help 2nd through 5th grade teachers integrate the concept of proof into their mathematics instruction. Through close collaboration with a group of teachers experienced in incorporating ideas of proof into their instruction, project staff plan to develop a small set of instructional routines that systematically engage students in developing habits of noticing, articulating, representing, and justifying general claims about operations in the context of core grade-level content. After the model is developed and refined through several iterations in classrooms of the experienced teachers, it will be implemented in classrooms with teachers inexperienced in incorporating such material. An important focus of the research is on how such instruction affects the learning of students who have been relatively successful and unsuccessful in achieving competency in numbers and operations.

Funder: National Science Foundation, DRK-12 (DRL-1019482)

** The SSD was funded in part by grants from NEC Foundation of America, the National Science Foundation (HRD-0533057), and the U.S. Department of Education (H327A060026). The SMD was funded in part by a grant from the National Science Foundation (HRD-0833969). The Signing Earth Science Dictionary was funded in part by a grant from the National Science Foundation (GEO-0913675).*

edge.terc.edu

TERC

2067 Massachusetts Avenue
Cambridge, Massachusetts 02140
617.873.9600 phone
617.873.9601 fax
www.terc.edu

Nonprofit Org.
U.S. Postage
PAID
Permit No. 375
Nashua, NH

MIX
Paper from responsible sources
FSC® C006060
www.fsc.org

Investigations for the Interactive Whiteboard

Investigations activities are now available on the interactive whiteboard. With support for every Session, teachers can use the interactive whiteboard to do the day's Classroom Routine or Ten-Minute Math, introduce a game or activity, facilitate a discussion, or illustrate a particular idea or solution. Students can use the whiteboard to play a game or do an activity during Math Workshop, and teachers can use these activities to work with small groups.

Differentiation and Intervention Guide

A flexible and versatile component to the Investigations curriculum units, these books offer further support in meeting the needs of the range of learners in any classroom. Available for Grades 1–5, they provide support for each Investigation, including:

- information about the important mathematics and help determining whether students understand, partially understand, or do not yet understand it
- an Extension, Practice, and Intervention activity, each with support for teaching English Language Learners
- blackline masters, including an optional quiz

Published by Pearson, learn more at www.investigations2.com