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)
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 bio-technology. And on page 8, Joni Falk and Brian Drayton discuss critical questions that impact the design of electronic professional learning communities.

— Kenneth Mayer
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 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.

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 helps others understand the underlying concepts, and asking that extra question that might seem obvious, but helps others understand the underlying concepts, and asking that extra question that might seem obvious, but helps others understand the underlying concepts, and asking that extra question that might seem obvious, but helps others understand the underlying concepts, and asking that extra question that might seem obvious, but helps others understand the underlying concepts.

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.

**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 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 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 and chose representations that could help build both their confidence and their mathematical understanding.

**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 educator as a separate person.
- 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.

The Accessible Mathematics project at TERC was funded by the National Science Foundation. Judy Storeygard@terc.edu. 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.

**REFERENCES**


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The Accessible Mathematics project at TERC was funded by the National Science Foundation.

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 adopt 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.”

**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 MSNet might be struck by the wealth of resources on math and science reform within the library and resource centers. However, members on MSNet 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 Barah) 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 Barah) 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 MSNet (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) encour-
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 interconnected 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.
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, 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.

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.

Taking photos from the window of the International Space Station.
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 Rekowsky is a researcher and freelance writer.

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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 to teachers to science careers.

Program Need
BioTeach is run by the nonprofit Massachusetts Biotechnology Education Foundation, whose ofﬁces over-look 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’ conscious-ness—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 did not align with their biology work in genomics, 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 troubleshoot facilities issues and find alternate materials. Evaluators helped BioTeach staff 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 understand 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 as an 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 satisfying to see the full picture.”

Polly Hubbard, Karen Mutch-Jones, and Janne Hennemann 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
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- 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

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

becoming routine—something I never imagined would my thinking had narrowed, and my teaching was myself to be on top of my game! Looking back, I realize received a master's degree in educational technology, seven years. I attended cutting-edge classes in college, journey. I had been teaching middle school science for I felt comfortably settled in my career as I began this after several years in the classroom, I did wonder whether 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 grumbling 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 poring 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
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 know 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 first day. From the first cycle, we learned that accommodations were the most effective.

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. Others 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 my 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 their; 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.

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

New Projects
Biodiversity-Transforming Innovative High School Curriculum
This project is developing a multimedia-enhanced version of the TERC-developed Biodiversity and the Habitable Planet (DRL-0628711) curriculum, a high school capstone science course. The biodiversity developers are designing additional UDL-aligned scaffolding to help more teachers use the material in heterogeneous high school science classrooms. The Biodiversity 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, DRL-12 (DRL-102089)

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 science education program available to middle and high school students—on students’ interest in, self-efficacy, and future plans in science. It employs a qualitative methodology with 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 Joyce Foundation

Facing 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: CIERES, University of Colorado-Boulder

Creating a Web Presence for the 13 Track
This two-year project is researching, designing, and facilitating a web presence for the National Science Foundation’s “Innovation through Instructional Integration” (13) program—a track instituted in 2008 to challenge United States 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 13 site will be designed around extensive user research and collaborative design principles. The proposed website will make the 13 track more transparent to stakeholders and the public to improve visibility of the 13 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)
components, developing a Flash-based movie for K–4 learners who are deaf or hard of hearing to educational content that will develop across multiple grades and years. The SLSD and SPSD will be disseminated on the Internet, with downloadable versions of the software available. Project researchers will develop and test the usability of the software, including features for students who are blind or visually impaired.

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 materials 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-1875060)

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

This study will examine the effect of the 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 Joyce 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, Sandown, and Timberlane); and Maine (Portland) to improve the teaching and learning of mathematics in K–5 classrooms 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 crucial and profound topics to reach all students. The impact of the project will be evaluated by the multidisciplinary research team.

Funders: Tufts University, 9 districts in Massachusetts, New Hampshire, and Maine.

Funder: National Science Foundation, MSP through Tufts University (DUE-0628685)

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

The Chico Kemper Center at TERC is collaborating with the Boston Teacher Residency of the Boston Public Schools to design, develop, and study a practice-based professional development model 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.

Funder: The Boston Teacher Residency of the Boston Public Schools

Funders: Department of Education, IES

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

Responding to a need for a coherent program in science, math, and language, this exploratory project is researching and developing a proposed grade 3–5 learning progression that provides a strong base for further inquiry in middle school. Project researchers will identify core concepts that will develop across multiple grades and structure the learning progression; interview children to identify concepts to develop for key concepts, as well as obstacles to learning them; work with teachers to conduct “teaching interviews” in urban after-school settings to elicit key concepts and understand students’ understanding of core ideas to progress; and design and disseminate the progression and blueprints with suggestions to extend the material to a complete K–12 energy learning progression.

Funder: National Science Foundation, DRK-12 (DRL-1020035)

Signing Math Dictionary 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 to 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 Earth Science Dictionary for grades 9–12.

Funders: Vcom3D

Funder: National Science Foundation (DRL-1019542)

Targeted Research for a Serious Games NSDL Pathway

EngE@TERC has been awarded a targeted research grant from SEENSDL to study the feasibility of creating a serious-games pathway for digital STEM resources. EngE (the Educational Gaming Environments group) will design and run a transmedia 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 Bubbles?” In the game, Bubbles is a white garnet 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 things out. The citizen scientists (serious gamers) will work together to monitor, analyze, and interpret coastal conditions, bird migration, and other environmental impacts 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, EngE will document the challenges and opportunities for STEM learning presented in using digital scientific resources in the context of serious games.

Funders: National Science Foundation, DRK-12 (DRL-0910814)

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** Partners: Vcom3D, Museum of Science, Boston; South Dakota: National Science Foundation, I/SEC (DRL-1009546)

** The NSDL Collaborative (DRL-0822278 and DRL-0822055) that examined the feasibility of creating a serious-games computing platform that could have in 4th and 5th grade science and math classrooms.

New Projects

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 will develop small set of instructional routines that systematically engage students in developing habits of noticing, articulating, representing, and justifying general claims about operations or sets of less 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.

Funders: National Science Foundation, DBK-12 (DRL-1020042)
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