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Project 2061

2061 today

Science Literacy for a Changing Future

Mathematics
Natural Sciences
Social Sciences
Technology

Fall 2002
Volume 12, Number 2

Solving the Equation

Project 2061 Studies Factors That Improve Student Learning in Mathematics

According to a recently released study of Title I schools conducted by the U.S. Department of Education, "students made greater gains in mathematics when teachers highly rated their professional development in mathematics and said that it matched their school's reform plan, focused on standards and assessments, and added to their confidence in using new approaches." This correlation between teachers' ratings of their professional development and student learning underscores the positive effect of quality professional development on the classroom. But to know more about how teachers can best incorporate effective instructional practices, the influence of professional development needs to be studied through classroom observations and in connection with factors such as curriculum materials. Project 2061's evaluation of middle-grades mathematics textbooks indicates that some materials have high potential for improving student learning, but empirical study is needed to show how these materials—and professional development related to these materials—can actually support effective teaching practices and improve student learning.

With a $5.8 million grant from the Interagency Education Research Initiative (IERI), Project 2061—in partnership with the University of Delaware and Texas A&M University—is contributing to this empirical work by studying how to provide, on a large scale, the professional development and continuing support teachers need to improve student learning of key ideas and skills in middle-grades mathematics. IERI, a unique joint initiative of the National Science Foundation (NSF), the Department of Education, and the National Institute of Child Health and Human Development, supports research aimed at improving the teaching and learning of reading, mathematics, and science from pre-kindergarten through grade 12.

Because the process of improving student learning is so complex and requires coordinated reform of many different parts of the educational system, no one factor is likely to improve student learning. Rather, it is the interactions among several factors that can lead to lasting improvements in student learning. To examine these interactions in the context of middle-grades mathematics, Project 2061's IERI study focuses on three questions:

- What is the relationship between teacher knowledge, the use of research-based instructional strategies—supported by highly

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rated curriculum materials—and student learning of specific ideas and skills?

- How does professional development and ongoing support—focused on specific mathematics learning goals—build teacher knowledge and lead to more effective teaching practices?
- How can technology help to provide effective teacher professional development and ongoing support cost-effectively on a large scale?

Photos: Theron Blakeslee

The research based on these questions will shed light and provide much-needed evidence on how multiple educational factors work together.

Putting Theory into Practice

To collect valid data on what and how teachers and students are learning, the study's researchers will use several research methods. "This study of curriculum materials and student learning will actually observe classroom practice instead of using teacher self-reports as a measure of what teachers are doing," said Jo Ellen Roseman, acting director of Project 2061 and principal investigator for the study. "In addition, instead of using off-the-shelf tests to measure student learning, our study will use not only the state tests that the students in Delaware and Texas are already taking but also assessment items specially designed to align with the particular benchmark ideas being used to gauge improved understanding."

Both the classroom observations and student assessments build on other areas of Project 2061's work. The analysis of classroom practice is guided by the same criteria and indicators used in the project's evaluations of instructional support in middle-grades mathematics and high-school algebra textbooks. Whereas the textbook evaluations provided theoretical information about the likely effectiveness of the curriculum materials, this study will provide empirical evidence about how research-based curriculum materials and teacher practices yield improved learning. The study's student assessment component draws on Project 2061's NSF-funded analysis of assessment tasks for their alignment to standards. By designing student assessments to align with the mathematics benchmarks used in the IERI study, researchers will be able to gauge more accurately what students have—and have not—learned.

Databases and Discussions

In keeping with IERI's emphasis on education reform strategies that use information and computer technologies, Project 2061 is using technology both to manage data collection and to enhance professional development and ongoing support for teachers. A computer utility developed by Project 2061 allows researchers to analyze video-recorded classroom lessons in relation to the lessons as they appear in highly rated textbooks. A detailed description of the program of activities and resources recommended in each textbook—that is, the literal program—provides a basis for monitoring, describing, and analyzing teachers' use of the material. Researchers can note, for example, which tasks are actually implemented in the classroom, what modifications are made, and what additional tasks are assigned. They can also make judgments about whether the teachers' lessons meet individual criteria for good instruction like providing a sense of purpose and providing experiences with relevant phenomena. Once classroom lessons are analyzed using the utility, teachers' patterns of use and modification of the curriculum materials will be related to patterns of student achievement.

The study will also document the potential that technology has for supporting, sustaining, and scaling up effective teaching practices. Video clips of teachers implementing the "literal program" of textbooks with varying degrees of fidelity will be used in professional development so that teachers can judge how well the enacted lessons support learning of important ideas and skills. These lesson clips, along with student work samples resulting from the lessons and other teacher support materials, will be made available to teachers via the Internet. In addition, ongoing technology-based support in the form of telecommunications networks will make possible on-line discussions among teachers in widely separated schools or districts. These technology-assisted opportunities for teachers to analyze their own teaching, explain their ideas, and demonstrate their skills to one another constitute one way that the study's professional development will model the same research-based principles of effective teaching that teachers are asked to include in their practice (see box on right).

With the IERI mathematics study well into its first year, plans are underway to design comparable studies of the factors that improve student learning in science. For more information about Project 2061's curriculum materials analyses, assessment analysis procedure, and professional development, visit www.project2061.org.

Principles of Effective Teaching

The professional development and ongoing support in Project 2061's IERI study are based on and will model the same research-based principles of effective teaching that teachers are asked to include in their classroom practice. Specifically, the professional development will do the following:

Provide a sense of purpose.
Rather than presenting principles of effective teaching as abstractions, professional development will be situated in relevant classroom teaching situations. The purposes of professional development activities will be explicitly stated and strategically sequenced.

Take account of initial ideas and skills.
Professional development will attend to prerequisite knowledge and skills, taking time to find out where teacher participants are starting from and helping them overcome both common misconceptions about mathematics learning and ineffective habits of teaching.

Provide experiences with relevant phenomena.
For professional development, the "phenomena" identified from case studies will be either instances of proficient teaching toward specific learning goals or instances where proficient teaching correlates well with improved student achievement of those goals.

Develop and use ideas and skills.
Professional development will use data collected to demonstrate to teachers the merit of the ideas and skills they will learn; model the use of research-based teaching practices; discuss essential aspects of the models and criteria by which teachers can analyze their own teaching; and provide opportunities for teachers to practice skills in their own classrooms and obtain feedback.

Promote thinking about experiences with phenomena, knowledge, and skills.
Teachers will have opportunities to explain their ideas and demonstrate their skills to one another; practice their interpretation and reasoning about mathematics ideas, learning, and teaching; and monitor their own progress.

Assess progress.
Teachers' learning will be monitored by questionnaires and interviews, observations of their classroom teaching practices, and analyses of their students' learning.

Enhance the learning environment.
Teachers will be shown how to improve their own understanding of mathematics ideas, learning, and teaching. Sessions will create a classroom environment that welcomes teacher curiosity, encourages a spirit of healthy questioning, avoids dogmatism, encourages high expectations, and enables every participant to experience success.

New CEO Leading AAAS—and Science Education—into the Spotlight

Dr. Alan I. Leshner, the new AAAS chief executive officer, has been a highly visible and active leader since taking on the role late last year. A psychologist and neuroscientist, Dr. Leshner previously served as director of the National Institute on Drug Abuse and director of the National Institute of Mental Health (NIMH). He began his career as a professor of psychology at Bucknell University, and has also held senior positions at the National Science Foundation (NSF) as deputy director of the National Science Board Commission on Pre-College Education in Mathematics, Science, and Technology and as acting director of the Division of Pre-College Materials Development and Research. Mary Koppal of Project 2061 spoke with Dr. Leshner recently about his views on science education, the role of AAAS in educating the public about science, and other important issues.

Those who don't have a fundamental understanding of scientific principles or scientific concepts are left behind…they are denied opportunities.

MK: What turned you on to science? Was it a particular teacher? What are your recollections of your education?

AL: I had a boring early education, generally, and went to college because smart people were supposed to go to college. I was originally going to be a music major, but became a biology major and thought I'd become a doctor. And then I met a professor, a research psychologist, whose lab I worked in. At the time there was a lot of interest in whether biochemical changes accompany learning experiences in simple organisms. I did studies of RNA and learning in planaria with him and decided I liked research, so I didn't go to medical school but instead became what is now called a neuroscientist (then called a physiological psychologist). The important point is that I, like so many other scientists, got caught up in science because of my research experiences.

MK: In all your roles, science education has been an important part of your work—directly at NSF—but where else has it come into play?

AL: I've always been interested in the issue of education in, and about, science. I always had a tie either to workforce development or to pre-college education. And then when I got to NIMH, I became involved in public education about what science could teach you about illness. Then I went to the National Institute on Drug Abuse, and I discovered that people thought that addiction was simply an issue of moral weakness or failure of will, when, in fact, addiction is a brain disease. I decided to mount a series of public education campaigns, using a variety of media, to educate the public that addiction is actually a health issue.

MK: So, thinking about all of this together, what are the big questions in your mind about science education?

AL: A big issue that concerns me greatly is: When we talk about education in science and technology for the non-specialist, what is it that we want people to know and carry with them through life? I think if we can get to young people in the schools and give them content, they'll have a tremendous leg up in the future, because the data are clear: Those who don't have a fundamental understanding of scientific principles or scientific concepts are left behind. It's not that they have miserable lives, but they are denied opportunities. And that's true in the United States and in other countries. One of the biggest complaints of developing countries is, "How are we to develop if we don't have sci-

entific infrastructure and scientific literacy?" What they want is science education, both for young people and for the public.

MK: What do you think is the most powerful argument we could make on behalf of science education?

AL: There was rhetoric in the early '80s around education commissions that actually spoke to the societal need—the rising tide of mediocrity—that would limit society's opportunity for growth. But the rhetoric from other commissions—from our National Science Board commission at NSF—was that children would become stragglers in the age of technology. And *both* of those are powerful arguments. One is a societal need and the other is a *humanitarian* need, that by denying people appropriate education, we are actually denying opportunity. And worse, if we educate people badly, we become enemies of science—and then they'd *really* be left behind.

MK: AAAS has played a leadership role in science education for many years. Do you see that mission changing? In particular, how does an association that publishes the foremost science journal, that publishes all the latest research, connect with the education initiative?

AL: AAAS is the largest general scientific society in the world, and therefore, its mission is extremely broad. It's both an opportunity and a responsibility to speak on behalf of the science and technology enterprise, and to explore science and technology to the benefit of all people. We work in a tremendously diverse range of areas, because we represent such a diverse community. Each of our goals represents areas in which AAAS has to work in order to achieve its overarching mission, which is to advance science and innovation throughout the world for the benefit of all people.

MK: Do you ever see a time when the general public would like to read the front section of *Science* magazine?

AL: I would be thrilled if the general public wanted to read the front of *Science* magazine. But our magazine ought not to be where the bar is placed. The bar ought to be placed in *The Washington Post*. If you can read about science in *The Washington Post* and not go, "Eh, I don't understand that stuff anyway," *that* would be progress.

MK: What kinds of challenges do you see for AAAS in communicating the benefits of science?

AL: The obstacles are the usual: money, training your scientists to speak to the public….

MK: What do you think is the role of Project 2061? What can it contribute?

AL: Project 2061 has done some things so far that are tremendously important. One is to set ambitious goals for the level of science understanding that we want young people to achieve. Second, it's contributed content by spelling out those goals in enough detail so that people know what we're talking about. Third, it's been helping people *implement* the content in the classroom and elsewhere. People don't automatically know what to do, so they need technical assistance. The question is what will be the appropriate future strategy to keep the momentum going, to make sure that the benchmarks and standards stay current with what science is revealing and that the technologies work right.

It's considered almost a truism that advances in cognitive science have taught us a tremendous amount about more effective teaching and learning. Yet it's not clear to me that those advances in cognitive science have been used at all. For 40 years, we've been studying cognitive processes, processes of learning and memory. The question is how do we translate these insights into real-life changes in the way people are *taught*, not in the way that they *learn*. That's a cop-out. That's putting the blame on the young person. We need to place the responsibility on the educational system, to use whatever these insights are to then facilitate learning.

MK: Taking into account all of the individuals and organizations that are acting on behalf of improvements in science education, what do you think is possible in the next five years?

AL: I think we need to form consortia with the major players, yet again, and try to get as much cooperation as we can. I hope that AAAS and the National Academy of Sciences will work together. I hope that the National Science Teachers Association and the rest of us will only work more closely. We have a common set of goals. We actually do relatively similar things, so I think the opportunity is there. The obligation is on us to make it work.

Dr. Alan I. Leshner, Chief Executive Officer of AAAS

We need to place the responsibility on the educational system, to use whatever these insights are to then facilitate learning.

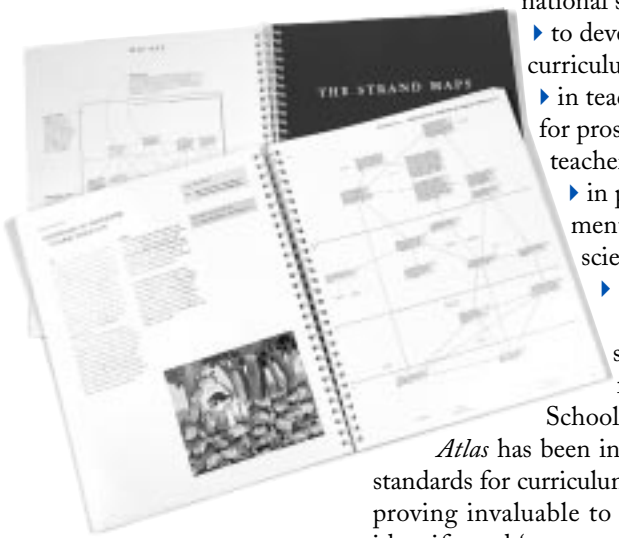
Popular *Atlas* Maps Have Digital Destination

Atlas of Science Literacy, published jointly last year by AAAS Project 2061 and the National Science Teachers Association, has proved a popular and useful education reform tool. Over 15,000 copies of the oversized book have been sold since its release and it is now in its fourth printing. Educators are using the conceptual strand maps and research-based commentaries in *Atlas* for a number of purposes, including curriculum revision, teacher training, and standard clarification and alignment. Meanwhile, Project 2061 is running *Atlas* workshops, developing additional maps, and exploring the possibilities of translating *Atlas* from print to digital form.

Abundant Applications

Atlas of Science Literacy aims to help educators understand how the ideas and skills that lead to literacy in science, mathematics, and technology might progress from kindergarten to grade 12. Educators can then use *Atlas* in designing coherent curriculum, instruction, and assessment. To find out whether *Atlas* is being applied in the ways its developers anticipated, Project 2061 recently conducted a Web-site–based survey. The more than 100 survey respondents reported that they are using the tool

- to strengthen their understanding of standards;
- to connect state and district standards to national standards;
- to develop, align, and revise curriculum;
- in teaching methods courses for prospective K–12 science teachers;
- in professional development programs for K–12 science teachers; and
- as a reference book.



For Patricia Marinac, science program leader for the Appleton Area School District in Wisconsin, *Atlas* has been instrumental in clarifying standards for curriculum development: "*Atlas* is proving invaluable to teachers as they try to identify and 'tease out' the essential understandings that students need that serve as the basis for more complex learning." To help educators like Marinac make the most of their work with strand maps, Project 2061 has been conducting three-day *Atlas* workshops in cities across the country. Fall 2002 workshops are taking place in San Francisco, California, October 10–12 and Miami, Florida, November 14–16 (see www.project2061.org/workshops for details and registration information).

Mapping New Ground

Although readers have found plenty to think about and do with *Atlas of Science Literacy*, the current set of maps graphically depict only half of the learning goals specified in Project 2061's *Benchmarks for Science Literacy*. The remaining maps are now under development and drafts of them will be made available on Project 2061's Web site, so they can be viewed and commented on before being published in book form. The approximately 50 new maps will cover topics such as weather and climate, the conservation of energy, the interdependence of life, and materials and manufacturing.

Work is also underway to develop an interactive, digital version of *Atlas*. Although the digital realm is a natural environment for the *Atlas* maps with their many links among learning goals, displaying the 12" x 15" maps on a computer screen makes them difficult to read when viewed in their entirety. But a digital *Atlas* could compensate for the computer screen's diminished view by offering users significant new capabilities. The tool could help users access a range of information, including research on student learning for each learning goal; diagrams, photographs, and other representations that can be used to explain a science concept to students; and sample lessons and assessments aligned to a specific learning goal.

Project 2061 has developed a prototype digital *Atlas* that allows you to jump from map to map when you select options such as viewing learning goals shared by more than one map. You can also select a section of a map and quickly zoom in and out. Funding is being sought to continue development of this early prototype. For more information about *Atlas of Science Literacy* and to view sample maps, visit www.project2061.org/tools/atlas.

About AAAS and Project 2061

Publisher of the peer-reviewed journal *Science*, the American Association for the Advancement of Science (AAAS) is the largest general scientific organization in the world. Its education initiative, Project 2061, has been at the forefront of the K–12 reform movement

- Defining science literacy and promoting it as a goal for all Americans;
- Developing K–12 benchmarks for student learning in science, mathematics, and technology;
- Producing a wide range of innovative tools for educators—books, CD-ROMS, and on-line resources—to guide their reform efforts; and
- Creating unique professional development experiences to help educators improve teaching and learning.

AAAS gratefully acknowledges the following Project 2061 supporters: Carnegie Corporation of New York, Hewlett-Packard Company, John D. and Catherine T. MacArthur Foundation, Noyce Foundation, David and Lucile Packard Foundation, Siemens Foundation, and the National Science Foundation.

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Director's Notes

Beyond Good Ideas

For over a decade, Project 2061 has enjoyed a reputation for developing high quality tools for educators. Our learning goals and guidelines for curriculum, teaching, and assessment have helped to shape national and state efforts to improve science education for all students. While a scientific society like AAAS may be listened to based on its reputation and the logic of its recommendations, we cannot expect educators to carry out our recommendations without evidence. Nor should we. That's why all of our work is built on and tested by research.

Research is at the core of our work with curriculum materials. We began in 1991 with a search for materials that would target the learning goals then being spelled out in drafts of *Benchmarks for Science Literacy*. By 1996, we were working on a procedure for examining both the content alignment and the quality of instructional support in science and mathematics curriculum materials. The criteria and indicators used in this procedure were based on available research on how students learn specific concepts, and guided our widely reported evaluations of middle- and high-school science and mathematics textbooks. While the evaluations identified a few good middle-grades mathematics texts, we found most of the textbooks inadequate for helping today's students learn the most important science ideas and skills.

Stimulating Materials Development

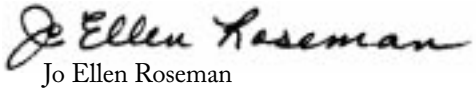
To promote the development of materials that are explicitly designed and tested to help all students learn, Project 2061 recently hosted a series of conferences with the goal of creating a realistic plan for improving science curriculum materials over the next five to ten years. The first conference focused on the critical features of highly rated materials. It became clear that the magnitude of changes needed in textbooks would not be produced without a significant research and development effort that involved the cognitive science and science education research communities.

Thus a second conference focused on how the research communities could contribute more productively to improving K–12 science teaching and learning on a large scale. But even as research agendas were being reconsidered, how could policies be harnessed to improve student learning? At a third conference, policymakers and educators discussed the role of state and district decision-making in supporting the development and use of high quality materials.

Getting Directly Involved in Research

Our latest efforts synthesize our work with curriculum materials and with teachers. Our IERI-funded mathematics study looks at how the interaction of highly rated curriculum materials and professional development can improve student learning. We are also partnering with the University of Michigan, Michigan State University, and Northwestern University to create an NSF-funded Center for Learning and Teaching dedicated to research on science instructional materials development and to fostering a new generation of leaders in materials development and implementation. And a new study, begun with start-up funding from the David and Lucile Packard Foundation and the Noyce Foundation, will examine the effects on learning when materials and teaching meet Project 2061's evaluation criteria and indicators.

More studies are needed, of course, and we encourage others to undertake them. It won't be easy, nor will it necessarily lead quickly to readily applicable findings. It took more than 30 years from Ignaz Semmelweis's "good idea" about the need for doctors to wash their hands (1847) to the acceptance of the germ theory of disease (1880), and another decade before rubber gloves were required during surgery (1890). Without the evidence from research, we might still be arguing about the benefits of hand washing.



Jo Ellen Roseman
Acting Director

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FYI

AAAS Re-States Association's Mission

The AAAS Board of Directors has issued a new statement of the organization's mission and goals. The newly worded mission, "To Advance Science and Innovation Throughout the World for the Benefit of All People," addresses the global context of the 21st century and reflects an expansion of the organization's leadership role on behalf of science. Among the seven broad goals set to fulfill this mission are two closely related to Project 2061's work: "Foster education in science and technology for everyone" and "Increase public understanding and appreciation of science and technology." For a full listing of the goals that provide the guiding framework for AAAS's programmatic activities, see www.aaas.org/about.

Assessment Project Making Strides

Project 2061 continues to evaluate the alignment of K–12 assessments in science and mathematics to national, state, and district standards. At the request of the South Carolina Education Oversight Committee, Project 2061 used its assessment analysis procedure to evaluate how well the newly developed 3rd and 8th grade science item banks of South Carolina's Palmetto Achievement Challenge Test (PACT) align with the South Carolina state science standards. South Carolina is using the findings from this evaluation and others to continue field testing and revising the assessment items. Project 2061 is drawing on the evaluation experience to refine aspects of its analysis procedure and evaluation process. Evaluations of science and mathematics assessments from at least two other states are planned for the coming year. Meanwhile, work has begun on case studies that illustrate the use of the analysis procedure to both design new assessment tasks and revise existing tasks for alignment with standards.

Key Publications Feature Project 2061

Articles by Project 2061 staff or about our programs have been featured in five recent education and mainstream periodicals:

- "Rocket Science" appeared in the April 2002 edition of *Kiplinger's Personal Finance*
- "Less is More: Trimming the Overstuffed Curriculum" appeared in the March 2002 issue of *District Administration*
- "Textbook Alignment" appeared in *The Science Teacher* and "Choosing Content That's Worth Knowing" in *Educational Leadership* (October 2001 editions)
- "Putting Textbooks to the Test," appeared in *ENC Focus*, Volume 8, Number 3, 2001

The full text of some of these articles can be accessed by visiting www.project2061.org/newsinfo/research.

Project 2061 on the Road

Visit our exhibit booth at the Association of Science-Technology Centers Annual Conference in Charlotte, NC, October 12–15 and the California Science Teachers Association Annual Conference in San Francisco, CA, October 24–27. Come see our newest resources for educators and talk to staff members about current projects.

Introducing…

Danielle Diffine has joined Project 2061 as senior financial analyst. She previously worked at the University of Arkansas for Medical Sciences in Little Rock as the grants manager in the Geriatrics Department. Diffine received her bachelor's degree in accounting from Harding University and her M.B.A. from Webster University in Little Rock.

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