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Science Literacy for a Changing Future

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Transforming Textbooks

Project 2061 Teams Up to Target K–12 Science Materials

Because many teachers depend on textbooks as a source of content, content organization, and classroom activities, textbooks and other instructional materials greatly influence what gets taught and how it gets taught. But, study after study has shown that most science materials available today fail to serve the needs of students or teachers. Decades of research have yielded insights on all aspects of science teaching and learning, including which instructional strategies are most effective and which ideas are vital for understanding basic science concepts. Yet, too often, instructional materials neglect to take advantage of these research findings. Instead, materials are full of unrelated facts, lists of terms to memorize, and colorful but uninformative illustrations.

Transforming instructional materials is the focus of a new center led by Project 2061 and funded by a $9.9 million, five-year grant from the National Science Foundation's Centers for Learning and Teaching program. The Center for Curriculum Materials in Science allows Project 2061 to play a major role in the future of science curriculum development and, as a result, to help all students gain essential science knowledge and skills. The work is carried out in collaboration with the University of Michigan, Northwestern University, and Michigan State University, along with school districts in Detroit, Chicago, and Lansing.

Creating New Knowledge

The Center's goal is improving K–12 science curriculum materials by making sure they reflect sound research on student learning and take advantage of the most effective teaching strategies and technologies, while supporting credible standards for what students should know, such as those in Project 2061's *Benchmarks for Science Literacy* and the National Research Council's *National Science Education*

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Toward High-Quality Materials

The Center for Curriculum Materials in Science and its programs reflect some basic principles for developing quality curriculum materials that are derived from the research and development work of the partner institutions. Among these principles are the following:

1. The centrality of clearly stated science learning goals.

To design high-quality instructional materials textbook developers need to specify the learning outcomes they have in mind for students.

2. The importance of building pedagogical supports into instructional materials.

High-quality materials do more than present content to students; they incorporate the most effective instructional strategies based on research about how students learn. Key pedagogical supports include taking account of student misconceptions, providing students with a sense of purpose, and using assessment and student feedback to inform instruction.

3. The usefulness of student investigations.

Instructional materials can help students to experience phenomena and work with models that are linked to science concepts. Materials can also help students engage in aspects of scientific inquiry like asking questions; planning experiments; and collecting, analyzing, and sharing data.

4. The value of incorporating learning technologies into instructional materials.

For the advantages of computers, software, and other peripherals to be realized, curriculum developers must learn to integrate these technologies effectively into instructional materials.

5. The need to serve diverse learners by designing instructional materials that are accessible to all students.

Instructional materials need to recognize and make provisions for the diversity of knowledge, learning needs, and experience, as well as social and cultural backgrounds, that young people bring to the classroom.

Standards. By drawing on the materials development and teacher education expertise of the partner universities, the Center's research and programs will address some of the problems Project 2061 previously identified in its evaluations of middle- and high-school science textbooks.

Research at Project 2061 and the universities will focus on how materials can be designed to help students achieve science learning goals and what key factors influence the adoption and successful implementation of highly rated curriculum materials. Research questions include the following:

- How can current knowledge about how students learn science inform curriculum materials design?
- How can learning technologies be used most effectively to promote student learning?
- What kinds of preservice and inservice teacher education experiences are most effective in promoting the selection and effective use of highly rated materials?
- How does policy influence the design, adoption, and use of curriculum materials?
- How can curriculum materials be constructed to make them most adaptable for local use?

The Center plans to use its research efforts to help define the national research agenda on how to improve the teaching and learning of science through curriculum materials.

Developing Leadership

A critical national role for the new Center is the development of a cadre of experts in science curriculum materials research and development. Each of the partner universities is expanding its graduate and postdoctoral programs in science education to include coursework and research opportunities in the analysis, design, and use of science curriculum materials. Beginning this fall, students will be admitted specifically to the newly developed Center programs at the partner universities. The doctoral programs will share these core elements:

- Courses in science curriculum design, assessment, learning theory, integration of learning technologies, teacher learning and professional development, and diversity and culture.

- Three new courses specifically designed for the Center that will focus on exploration and design principles for curriculum development; analysis, selection, and implementation of instructional materials; and the study of curriculum enactment.
- Practica on curriculum design, evaluation, and implementation, which may include internships at partner institutions, work with materials developers and publishers, and participation in projects with personnel in local schools.
- Research apprenticeships for ongoing projects.
- Dissertations related to the field of curriculum materials analysis, development, and implementation.

The partner institutions are currently recruiting graduate and postdoctorate students who will be committed to the Center's work.

Photo by Barry Fishman © 2003

Partners in Progress

Rather than becoming confined to ivory towers, the Center collaborators will also enlarge and strengthen existing partnerships with their local school-district partners to connect university research and teacher training (for both education students and current teachers) with the realities of the classroom. Over a two-year period, the Center will offer cohorts of approximately 30 teachers and administrators at least 100 hours of sustained professional development on instructional materials analysis, selection, and implementation. The professional development courses will be designed to connect with classroom practice, supporting teachers' attempts to adapt and enact curriculum. Currently, the Center's staff is developing a module that incorporates the Project 2061 instructional criteria for evaluating curriculum materials for use in elementary and secondary science methods courses. The module can be customized for instructing preservice or inservice teachers not only in science but also in mathematics.

A Knowledge Sharing Institute will become the intellectual core of the Center. The institute will foster the regular exchange of information, resources, and expertise within the Center as well as in the larger community of science educators, researchers, and curriculum developers. It will allow researchers, faculty, and doctoral students from other institutions—along with K–12 teachers and school administrators—to learn about the program's work. Ongoing videoconferences and other activities will help create a community of learners who learn from each other and from experts outside their own institutional settings. A week-long session this summer focused on the current state of the field. Through a series of white papers and invited speakers, participants shared existing knowledge about instructional materials and discussed plans for advancing that knowledge through research and development efforts.

The Center will help jumpstart the textbook transformation process. According to Jo Ellen Roseman, director of Project 2061 and of the Center, the new efforts will "foster essential research and development aimed at helping all students learn what they need to know to thrive in our science-based world."

To learn more about the Center for Curriculum Materials in Science, visit **www.ScienceMaterialsCenter.org**. For specific application procedures and deadlines, please contact the partner institutions:

Michigan State University
Dr. James Gallagher, Science and Mathematics Training Center, 517-432-4871, gallaghr@msu.org

Northwestern University
Dr. Daniel Edelson, School of Education and Social Policy, 847-467-1337, d-edelson@northwestern.edu

The University of Michigan
Dr. Joseph Krajcik, School of Education, 734-647-0597, krajcik@umich.edu

How You Can Help

Enclosed in this issue is a reply envelope you can use to support Project 2061's work directly through the AAAS Fund for Excellence. In giving to the fund, you help friends and colleagues at AAAS tackle time-sensitive education, research, and technology related needs and problems. You can also contribute to Project 2061 online at http://aaasdev.aaas.org/giving/donate.shtml. **Your support is deeply appreciated.**

Digital Library Opens Window onto How Students Learn

Dr. Matthew Schneps is director of the Science Education Department's science media group at the Harvard-Smithsonian Center for Astrophysics (CfA) in Boston. Schneps is leading the CfA's Harvard-Smithsonian Digital Video Library project funded by the National Science Foundation's National Science, Mathematics, Engineering, and Technology Education Digital Library (NSDL) program. Catherine Tramontana of Project 2061 recently interviewed Schneps by e-mail about the CfA's video collection and the role of Project 2061 in helping to develop it into a resource for K–12 science educators.

Studying this footage, one can learn a great deal about how lessons on complex topics…need to be constructed, and what ideas students need to draw upon to make sense of the science.

CT: Could you characterize the kinds of video materials in the CfA's collection and how they have been used in the past? How many hours of video are in the collection?

MS: We are collaborating with AAAS to sift out the highest quality science education video from a total collection of about 3,500 hours. Culling this material is a mammoth undertaking: for one person to watch 3,500 hours of video would take almost two years of full-time work. So a large part of the project is finding ways to select the best video efficiently.

The materials in our collection include videos like *A Private Universe*, the documentary that features Harvard graduates being interviewed about the seasons, and *Minds of Our Own*, which has some classic interviews with children about photosynthesis. Generally speaking, the collection consists of "clinical interviews" with children, talking about their preconceptions in science; "classroom examples" documenting teachers carrying out various lessons; "science explanations" that include things like an animation of an apple rotting over time; and "expert interviews" with various teachers, scientists, education leaders, and others who have interesting ideas on science education.

CT: What makes these materials so valuable in the context of science education reform?

MS: The key to the value of this collection, and to the NSDL at large, is that the materials will be organized in a way that allows teachers to quickly find materials relevant to their interests, obtain these materials over the Web, and use them in ways they feel are the most valuable.

More specifically, in terms of our collection, teachers have told us time and time again that it is very unusual for teachers to have an opportunity to see how other teachers go about their work. Our videos can provide glimpses into a classroom and insights on teaching practice. By allowing teachers to study entire classes uncut, for example, student teachers will be able to learn different ways to present their ideas.

Other valuable things in the collection include the "clinical interviews" with students. Interviews like these are extremely rare and difficult to produce. Short segments of many of them have been seen in programs such as *A Private Universe*. The uncut interviews that we would include in the NSDL often contain insights into science learning that could not be included in the television programs because of time limitations. By making these interviews broadly available, teachers and educators will be able to see for themselves how students actually learn science.

CT: Could you describe a specific piece of footage that represents well the value of the collection to educators?

MS: A good example might be interviews with some of the acknowledged leaders in science education, such as the late Rosalind Driver. Professor Driver's books and research papers

are very well known, but probably very few teachers have read these papers, or heard Professor Driver speak. Collections of such interviews provide teachers with easy access to the important thinkers and big ideas that have shaped science education.

Another example is a clinical interview with Jon, a student who is talking about where the mass in a tree comes from (it comes from the air). The interview traces in detail why Jon has such trouble understanding the ideas his teacher puts forth in class. Studying this footage, one can learn a great deal about how lessons on complex topics such as photosynthesis need to be constructed, and what ideas students need to draw upon to make sense of the science.

CT: What contributions are Project 2061 and its benchmarks for student learning making to the digital library? How are the strand maps in *Atlas of Science Literacy* informing your work?

MS: Project 2061 is helping us decide which things are of the most value to teachers. In addition, Project 2061 is helping to link these materials to specific benchmarks and to construct a Web interface so that teachers can search for resources in ways that make sense to them. The *Atlas* strand maps are key to this process because they help us understand how various ideas interrelate. Thus, the strand maps will literally connect our materials to the vast network of ideas taught in science.

CT: Why is it important to connect the video materials to specific benchmarks or learning goals? Could you describe briefly the process you are using to relate the materials to learning goals?

MS: One of the things that learning goals like benchmarks provide is an organizing framework to help us understand which ideas are most important for children to learn. To link our video clips to this framework, we first select materials that we feel are most interesting or valuable. Then Project 2061 will examine these clips to determine whether or not they tie to particular benchmarks. This information will be entered into a database that tags our video clips to specific learning goals.

Photo by Randy H. Goodman © 2003

Matt Schneps (left) at work for the Harvard-Smithsonian Center for Astrophysics' Science Education Department.

CT: How do you see the digital video library being used by educators?

MS: Teachers and others will discover their own uses for the materials in this collection, and we probably won't be able to foresee many of these uses. However, it's clear that some teachers will look to this collection to find video clips to share with their students. Others might use the clips as part of their professional development, to learn more about some difficult science topics or to hone their teaching skills. Others still may use the clips as raw material for teacher education courses or workshops. Some educators are likely to use the videos as data that will support further research into science learning.

The concept of the NSDL, a national digital library for science education, is far-reaching and brand new. It's difficult to predict how this tool may be used by educators over time. However, it's an idea whose time has come, and we're excited to be working with AAAS Project 2061 in pioneering this new resource.

To learn more about the Harvard-Smithsonian Center for Astrophysics and its work, visit **cfa-www.harvard.edu/sed/projects/dvl.html**. For more information on the NSDL, go to **www.ehr.nsf.gov/ehr/due/programs/nsdl**. To view information on Project 2061's *Atlas of Science Literacy*, including sample strand maps, see **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 online resources—to guide their reform efforts; and
- Conducting research on the design and use of curriculum materials, assessment, professional development, and other areas of science 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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www.project2061.org/about/order.htm.

Focusing Families on Science

Science is all around us, and a good science education can help give kids a great foundation for success in life. That's the message of the Partnership for Science Literacy and its new public awareness initiative launched by AAAS through a National Science Foundation grant to Project 2061. "Science. It's Everywhere" aims to increase awareness among parents and families—particularly those in Latino/Hispanic, African American, and other minority communities—of the value of science literacy for all children. The initiative invites parents to make a difference in their children's science education by doing science activities around their home, exploring science centers and activities in their community, and making sure there is quality science in their schools.

"Science. It's Everywhere" combines grassroots efforts with a national multimedia campaign. Regional kickoff events hosted by local science centers took place in May and June in five diverse communities across the country: Los Angeles, California; Chicago, Illinois; Tampa, Florida; Lehigh Valley, Pennsylvania; and Austin, Texas. Public service announcements, endorsed by the Advertising Council, are bringing the "Science. It's Everywhere" messages to the public in both English and Spanish. A free Family Guide to Science booklet presents useful information and hints on science activities for parents and families (to order, call AAAS toll-free at 1-888-737-2061). The initiative's Web site, **www.ScienceEverywhere.org**, is hosted by TryScience.org and provides additional information about science education along with links to electronic science resources for children and adults.

The Partnership for Science Literacy draws on the expertise of Project 2061 and the AAAS Directorate for Education and Human Resources. The Partnership is building a coalition of local and national organizations to empower families to improve their children's interest in and learning of science.

Visit "Science. It's Everywhere" at www.ScienceEverywhere.org!

Project 2061 Tool Reaches 10th Anniversary

It is an unusually shaped book at nine inches square and features bold amber-to-red triangles on its glossy white cover. It is more than 400 pages long and helps thousands of science educators in their daily work. The book is *Benchmarks for Science Literacy* and this year marks the 10th anniversary of its publication.

Benchmarks is the Project 2061 statement of what all students should know and be able to do in science, mathematics, and technology by the end of grades 2, 5, 8, and 12. With more than 120,000 copies sold since 1993, *Benchmarks* has made a significant contribution to the standards-based reform movement. Educators across the country have used *Benchmarks* to shape their curriculum, instruction, assessment, and teacher training.

Share Your Experiences. To gauge how *Benchmarks* has been used over the years and take stock of its value to science educators today, *2061 Today* would like to hear from teachers, supervisors, principals, and others—anyone whose work on behalf of K–12 science education has been influenced by *Benchmarks*. When did you first encounter *Benchmarks*? How has using it changed your work? What has *Benchmarks* made possible for you and your students?

Please e-mail comments of 75 words or less to project2061@aaas.org (write *Benchmarks!* on the subject line) or mail comments to AAAS/Project 2061, Attn: *2061 Today*, 1200 New York Avenue, NW, Washington, DC 20005. Please include your name, title, and affiliation. Selected responses will appear in a future issue of *2061 Today*.

Director's Notes

Reform's First Steps: Alignment

As our new Web site home page illustrates so clearly, learning goals are at the core of all that we do at Project 2061. With the 10th anniversary of *Benchmarks for Science Literacy* this year, we are reminded that aligning curriculum, instruction, and assessment to goals for student learning is an essential—but by no means easy—first step toward real reform. Based on a decade of work with teachers, researchers, curriculum and test developers, and publishers, we've come to appreciate just how difficult it is to achieve alignment that is more than a trivial keyword or topic match. Yet without careful alignment, many of the goals-based reforms that have the potential to improve students' science literacy will be impossible to achieve.

Hard Choices

Why is alignment so important? What difference does it make if textbooks or lessons include activities that are not carefully aligned to learning goals? It comes down to hard choices about the use of limited instructional time. Research has shown that it takes most students—even our brightest ones—much longer to learn science concepts than had previously been thought. To prevent materials from being "overstuffed and undernourished" and to give students an adequate opportunity to learn the most important ideas well, we have to set priorities for learning and teaching. Well-crafted learning goals can help.

Benchmarks, for example, recommends that students learn selected concepts that are important but not necessarily easy for students to grasp—such as fundamental ideas about photosynthesis, the kinetic molecular theory, and processes that shape the Earth. These ideas are spelled out specifically in *Benchmarks* and are included as goals because there was broad consensus within the scientific and education communities on their importance. Again, research tells us that teaching so that students truly understand ideas (rather than teaching so that they can recall technical terms) requires much more time than we now provide—time for taking into account what students already know about a particular idea; time for engaging students in observing, experiencing, and explaining natural phenomena in terms of specific ideas; and time for encouraging students to apply their new knowledge in a variety of contexts.

Radical Reform

Why is alignment to goals so difficult to achieve? Our experience suggests that goals-based reform is far more radical than it may first appear. The very specificity, sequencing, and coherence of the learning goals in *Benchmarks* require significantly different ways of thinking about alignment and its effect on the content and delivery of the science curriculum. In our studies of science textbooks we found that even when textbooks cover the key ideas, most fail to make the connections among ideas that would help students assemble a coherent story out of otherwise isolated bits of information. Our reviewers required evidence that the content was aligned to the specific goals, presented coherently, and in ways likely to help students understand and use it.

Ten years ago, we did not fully appreciate how challenging the issue of alignment would be. Today, through our work with university partners, students, and teachers in the new Center for Curriculum Materials in Science and in other research projects, we have an opportunity to focus on careful alignment with goals as the starting point for improving instructional materials, assessments, teacher preparation, and leadership in science education.

Jo Ellen Roseman

Jo Ellen Roseman
Director

Without careful alignment, many of the goals-based reforms that have the potential to improve students' science literacy will be impossible to achieve.

FYI

We want to hear from you!

- Tell us what you think of *2061 Today* by participating in our survey at **www.project2061.org/newsletter/survey**.
- Get your newsletter faster and help us cut mailing costs by signing up for *2061 Today*'s online subscription list at **www.project2061.org/newsletter/online**.

Online Overhaul

Project 2061 has redesigned its Web site. Users can now access announcements, articles, and resources through five main areas: Learning Goals, Curriculum Materials, Testing & Assessment, Family & Community, and Research on Teaching & Learning. In addition, educators, parents, and the media can search for information specific to their interests. Visit **www.project2061.org** for a closer look at the new content, new graphics, and easier navigation.

Staff Win Distinguished Paper Award

The National Association for Research in Science Teaching (NARST) has presented Project 2061 staff with NARST's 2003 Distinguished Paper Award. The winning paper, "How Well Do Middle School Science Programs Measure Up? Findings from Project 2061's Curriculum Review," was published in the *Journal of Research in Science Teaching* (*JRST*), the leading international journal for science educators published by NARST. Authored by Program Director Sofia Kesidou and Director Jo Ellen Roseman, the paper describes Project 2061's landmark evaluation of how likely middle-grades science textbooks are to support the teaching and learning of key science ideas. The evaluation found that the majority of the texts fall short in presenting the material effectively. The full text of the paper is available online at **www.project2061.org/research/curriculum/jrst.htm**.

Atlas Workshops in 2003

Project 2061 is pleased to announce new workshops introducing *Atlas of Science Literacy*. These three-day workshops give participants some firsthand experience in using *Atlas* and other Project 2061 tools to promote science literacy and build an effective curriculum. Workshops will take place August 21–23, 2003, at the Peggy Notebaert Nature Museum in Chicago, IL, and October 15–17, 2003, at AAAS in Washington, DC. Please see **www.project2061.org/workshops** for registration forms and details.

Project 2061 at Association of Science-Technology Centers Conference

Project 2061's exhibit booth will be at the Association of Science-Technology Centers (ASTC) Annual Conference in St. Paul, MN, November 8–11. Come see our education reform tools, find out about the project's latest research, and learn about "Science. It's Everywhere," AAAS's public awareness initiative. (Visit **www.ScienceEverywhere.org** for more details.)

Introducing…

Mercy Ngone is a visiting fellow working with Project 2061 and the Directorate for Education and Human Resources. Her summer work at AAAS—including research aimed at improving life science curriculum materials—culminates her year as a Hubert H. Humphrey Fellow at the Pennsylvania State University. Ngone is a national pedagogic inspector for biology/secondary general education for the Republic of Cameroon's Ministry of National Education. She holds a first degree in life sciences from the University of Yaounde-Cameroon and a master's degree in animal science from the University of Ibadan-Nigeria. **Alison Pruitt** joins the Project 2061 communications department as a writer. Pruitt's previous experience includes teaching at McDaniel College and Rutgers University, and writing and editing for the National School Boards Association. She holds a Ph.D. in literatures in English from Rutgers University.

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