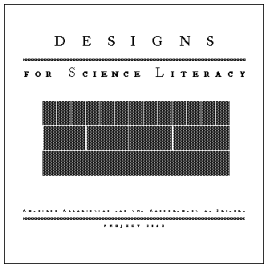
Project 2061
American Association for the Advancement of Science

Designs for Science Literacy

Guiding K-12 Curriculum Reform

This summer with the release of its latest publication, *Designs for Science Literacy*, Project 2061 offers some guiding principles and practical advice to help educators in their efforts to reconfigure the entire K-12 curriculum—the total educational experience—to achieve science literacy. The book proposes ways to design, for grades K-12, a curriculum that aligns well with established learning goals and that systematically and logically connects subjects and grade levels. An accompanying CD-ROM contains information and databases to help schools get started.



Why Curriculum Reform?

In spite of many reform attempts, the 20th century has ended with virtually the same curriculum it started with—a curriculum that does not effectively teach what students most need to know and that does little to improve student achievement in science, mathematics, and technology. Although students may do well on exams in algebra and biology, for example, extensive research shows that most of them really understand and retain very little of the content. Inadequate textbooks and other deficiencies play a part in all these problems, but the structure of the curriculum itself is oftentimes a major source of trouble.

Much of the typical curriculum today is obsolete, fostering little of what is needed for literacy. It is usually assembled from unrelated fragments, without reference to a conceptual whole and with no coherence across grade levels or subject matter. Curricula tend to cover too many topics, far more than can be taught effectively during the average school year. Curricula also tend to lack the sensitivity or flexibility necessary to meet the needs of diverse student populations.

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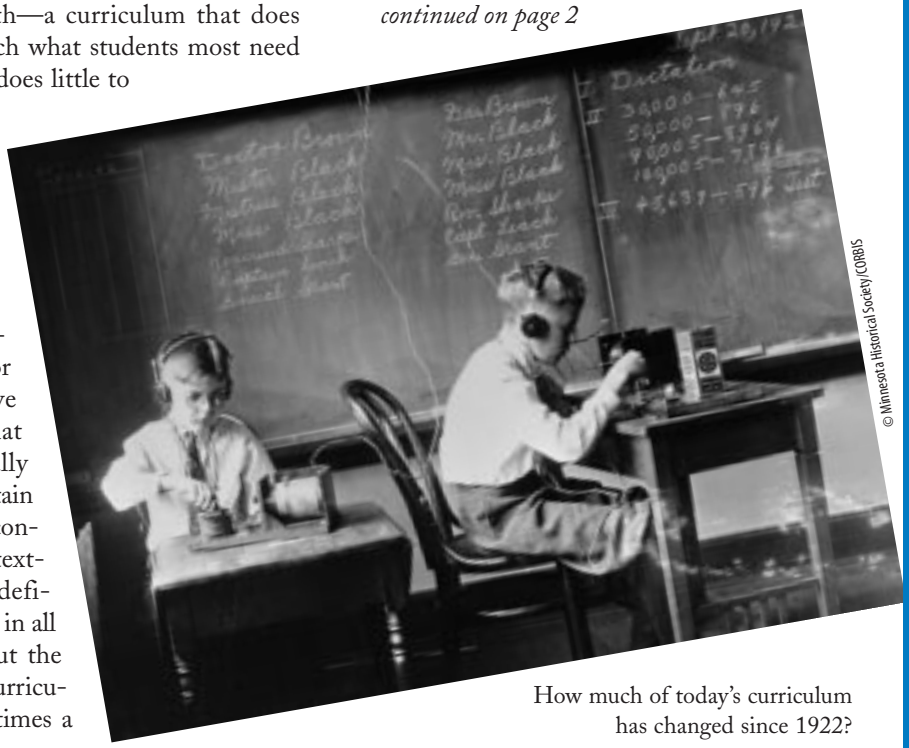


How much of today's curriculum has changed since 1922?

2061 today

Science Literacy for a Changing Future

Mathematics

Natural Sciences

Social Sciences

Technology

Spring/Summer 2000
Volume 10, Number 1

Getting Started Now

Designs for Science Literacy suggests steps that school districts can take now to make significant improvement in the current curriculum while pursuing a long-term reform strategy, including:

Building Professional Capability

If school districts are to achieve curriculum reform, it is essential that they build a professional capability for undertaking curriculum change. Through concentrated effort and coherent professional development programs, educators can:

- increase their science literacy by taking courses, reading recommended background books, and by pondering patterns of conceptual growth towards literacy proposed in Project 2061 strand maps;
- deepen their understanding of student learning goals by studying strand maps, weighing instructional topics against specific learning goals, and participating in and conducting Project 2061 workshops;
- become familiar with research on student learning; and
- learn to analyze curriculum materials for their alignment to learning goals.

Unburdening the Curriculum

Because time in school for teaching and learning is not limitless, "coverage" almost always wins out over student understanding. Improvements in curriculum design and teaching methods may eventually make it possible for students to learn more than they do now. Until then, *Designs for Science Literacy* offers four strategies that can help to make room for teaching the most important concepts and skills well, including:

- reducing the number of major topics taught,
- pruning unnecessary details or subtopics,
- de-emphasizing technical vocabulary in order to focus only on the most essential terms, and
- eliminating wasteful repetition.

(See interview on pages 4 and 5 for more information)

Increasing Curriculum Coherence

In many school districts the subjects making up a curriculum in any one year have little to do with one another or with the same subjects in the previous or subsequent years, resulting in a curriculum that does not optimize student learning. To improve curriculum coherence over grade levels and across subjects, educators can:

- form cross-grade curriculum planning groups to ensure a logical developmental sequence of important knowledge and skills, and
- explore thematic connections between science-related subjects and other fields.

Designs for Science Literacy, with the *Designs on Disk* CD-ROM, is available from Oxford University Press for a prepublication price of $32.50. Order by mail or phone from: Oxford University Press, Ordering Department, 2001 Evans Road, Cary, NC 27513 Telephone: 1-800-451-7556 Web Site: http://www.oup-usa.org

How *Designs* Can Help

Designs for Science Literacy asserts that the application of general principles of design can have a significant payoff in the quality of the K-12 curriculum. A curriculum is naturally rich in design activity: design of lesson plans, design of instructional materials, design of courses, design of course sequences. But these design activities are often piecemeal and isolated. In other areas of human endeavor (manufacturing, agricultural distribution, or military operations, for example) the design of whole systems renders great benefits—parts work better together, redundancies and gaps are reduced, and less redesign and adjustment are needed. *Designs* contends that educators can reap similar benefits by using design principles to create a single, cohesive K-12 curriculum. Using these design principles as a guide, the book offers techniques and strategies for aligning K-12 curriculum with specific learning goals such as those recommended in Project 2061's *Benchmarks for Science Literacy*, national standards in science and mathematics, or state and local frameworks. *Designs* does not provide step-by-step instructions for creating a curriculum, but offers a variety of options for restructuring time, instructional strategies, and content. *Designs* illustrates how to approach curriculum design in many different ways and to create many different curricula that can promote the attainment of learning goals.

Using Curriculum Blocks

Designs operates on the premise that good curriculum design should attempt to optimize learning across the entire curriculum, not just unit by unit, subject by subject, or grade by grade. To the degree that curriculum design for the whole K-12 range is done at all, the task is usually divided into nearly independent parts. The trouble is that the parts usually do not get put back together to form a coherent whole that optimizes students' learning throughout grades K-12.

Project 2061's alternative approach is to design curricula by selecting and configuring large curriculum "blocks," potentially ranging in duration from a few weeks to a year or more of study. The notion of curriculum blocks focuses attention on having a wide variety of

components from which curricula can be assembled and on having precise descriptions of blocks that will enable educators to make informed choices and placements in designing curricula. *Designs* explains blocks, what they could look like, how they could be configured, and how they could most helpfully be described (see sidebar).

Who Should Use *Designs* and How?

Designs is written for administrators, curriculum designers, educational reform leaders, teacher educators, and developers and publishers of instructional materials. It is intended to be used in the following ways:

- By administrators to organize curriculum change efforts in a way consistent with the national vision of science literacy.
- By developers and publishers of instructional materials to adopt a conceptual framework for creating and revising their products to achieve specific learning goals.
- By designers of the K-12 curriculum to consider the science, mathematics, and technology components of the curriculum as a potentially coherent whole.
- By education reform leaders to introduce short-term improvements that will also contribute to significant long-term curriculum change.
- By college faculty and professional development specialists to teach the principles of curriculum analysis and design to new and experienced teachers.

Designs on Disk

Designs devotes careful attention to describing how a full-fledged computer-based system could be used in curriculum design. The *Designs* companion CD-ROM, *Designs on Disk*, demonstrates the kinds of functions the curriculum design software can carry out and provides aids to assist in carrying out recommendations from the book. Some *Designs on Disk* databases allow users to share and discuss their thinking about several aspects of reform, encouraging educators from a single school or school district to work collaboratively on the design process. To promote curriculum coherence, for example, the *Designs on Disk* CD-ROM provides a utility for cooperatively assigning benchmarks to specific grades. The *Designs on Disk* bibliography includes references to—and sometimes the full text of—articles on alternative formats of instruction.

Designs for Science Literacy provokes fresh thinking about how to move beyond marginal change in the curriculum. It takes a systemic approach to curriculum design and reform, weighing constraints that curriculum design teams will face and addressing aspects of the education system that must be considered in any careful re-thinking of the curriculum. At the same time, it challenges traditional curriculum and instruction and suggests alternatives that school districts can build on or adapt (or ignore) as they see fit.

Curriculum Blocks

In the future, Project 2061 envisions that a national inventory of high-quality curriculum blocks that target specific learning goals will be available. Using local, state, or national learning goals as a framework, different school districts' curriculum design teams would end up with different arrays of blocks that best serve their individual contexts. Following are ideas, developed with the help of Project 2061's six School-District Centers, that illustrate the variety of curriculum blocks that could be developed for the national inventory:

Applications blocks emphasizing the use of science, mathematics, or technology. Examples: Chemistry and Society; Public Opinion Polling; Science and Crime Detection.

Case study blocks in which the content is organized around one or more case studies that focus on historical episodes, social issues, or technological problems. Examples: Darwin's Finches; the Chemical Revolution; Brecht's Galileo.

Design blocks organized around design challenges for students to respond to individually or in groups. Examples: Energy Conservation; Measuring Time; Remote Controls.

Cross-cutting blocks that link science, mathematics, or technology to other domains. Examples: Architecture; Dinosaurs and Dragons; the Panama Canal; Evidence in Law and Science.

Explanation blocks that are designed to help students understand phenomena, objects, and systems. Examples: Fire; Growth and Decay; Science and Technology Underground; Plagues.

Exploration blocks that examine a place or time from the perspective of science and technology. Examples: Science and Technology in Ancient Egypt; the Lewis and Clark Expedition; Science Underwater; Science in Space.

Inquiry blocks that engage students in designing and carrying out scientific investigations to foster an understanding of how science goes about its work. Examples: Objects in Motion; Neighborhood Insect Species; Traffic Patterns.

Unburdening the Curriculum

Results of international studies show that the countries that score best in science at the secondary level tend to cover fewer topics than we do.

New content has been added to our K-12 curriculum year after year, but little has ever been subtracted, leaving us with science and mathematics curricula that are horrendously overloaded. Chapter 7 of the soon-to-be-released *Designs for Science Literacy* offers suggestions for how excess material can be trimmed from the curriculum. Recently, Project 2061 founder James Rutherford and associate director Andrew Ahlgren discussed Chapter 7 of *Designs* with Clarissa Evans, science supervisor for Howard County in Maryland.

CE: Chapter 7 is entitled "Unburdening the Curriculum." What led you to recommend the ideas in this chapter as key components of curriculum reform?

AA: Students need to learn with greater depth. But to have the time needed to emphasize quality of understanding rather than quantity of information presented, the sheer amount of material that today's science curriculum tries to cover must be significantly reduced. The suggestions in Chapter 7 of *Designs for Science Literacy* are meant to encourage schools to concentrate on the most important concepts and skills and to eliminate those that are less important. This chapter also offers some guidance for how this might be accomplished.

JR: What Chapter 7 does *not* say is "here are the things you absolutely should not teach." Instead it says "we know that courses are overcrowded and you need to leave something out to make some room; here is a list of strong possibilities." So it isn't quite saying you have to ax all these things out. It's saying you need to make time, and here are some things to consider.

CE: What research supports a "less is more" approach?

JR: Results of international studies show that the countries that score best in science at the secondary level tend to cover fewer topics than we do. On the other hand, maybe the burden of proof should be on showing that "more" works. Here we are cramming more stuff into the curriculum; we ought to have some evidence that doing this will cause learning to occur.

CE: What portions of *Designs* do you recommend to help readers understand the proper context of Chapter 7?

AA: They should probably read Chapter 6, the professional development chapter, first. It illustrates that unburdening the curriculum is not just a quick fix, but a matter that requires study and work. Chapter 6 also talks about using the progression of understanding strand maps because you want to be careful not to take things out of a curriculum that might be essential for understanding something else later.

CE: One major recommendation in Chapter 7 is that teachers eliminate some of the specialized terminology that they teach in their science classes. However, a lot of teachers are preparing students for state assessments that require students to know this terminology. What are the implications of your recommendations in light of the current state testing programs?

JR: It just shows us that the state testing programs have a long way to go. Since terminology is the easiest thing to test for, most of them are taking the easy way out. Maybe over time educators will put pressure on the system to revise the tests more in the direction of conceptual understanding rather than terminology. I suppose if you were actually in that situation you could go through and look at the state test, see which terms are showing up and eliminate from the curriculum some of the ones students won't need to know.

CE: Some of the topics and sub-topics that are listed in Chapter 7 as candidates for exclusion from the curriculum are considered general literacy topics—like acids and bases—that some students are going to learn even if it's not part of the public school system's curriculum. What are your insights about general literacy topics?

AA: Some scientific terms and concepts are probably learned well enough in general life without taking time out to teach them in school. Acids and bases are a good example. The benefit-to-cost ratio of investing instructional time to achieve a deeper understanding of these kinds of terms is often prohibitive. We

do have benchmarks that say everyone should have some level of awareness of general literacy topics, but the cost of teaching them in the classroom might outweigh any advantage.

CE: A lot of teachers would find it difficult to teach some of the concepts in *Benchmarks* without using the kind of details Chapter 7 recommends excluding. How are the recommendations actually going to play out in terms of everyday instruction in the classroom?

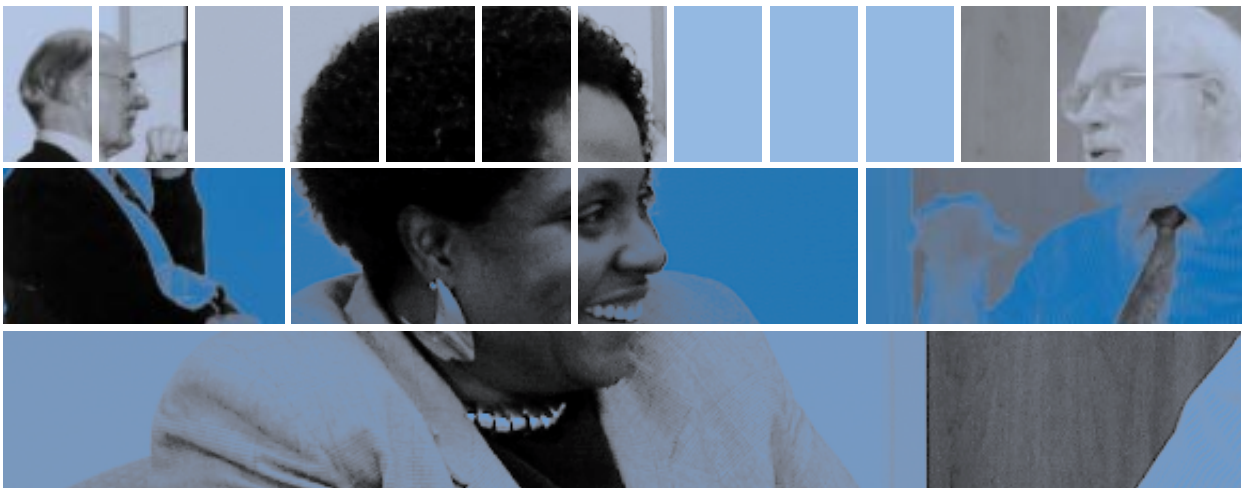
JR: I hope to see educators develop new courses that get at the main ideas in *Benchmarks* and *Science for All Americans* and, at the same time, limit the amount of details that are covered. With the appearance of instructional protocols and formats with different degrees of detail in them, one can begin to put these to the test and see how they actually work in practice. If you have more detail, how much longer does it take? How much better is the learning and so forth. I suspect that drawing their attention to details that we claim can be trimmed from a concept will promote a serious discussion about how much detail you actually need. So whether in the end they agree with our delineation is less important than that they seriously deal with the issue.

AA: You do have to use some details in teaching a more general idea. But I think Jim's point is the right one; teachers should take responsibility for the density and the use of details. They should wrestle with it and say, "do I need all of these things?"

CE: How would you respond to the teacher who agrees with your basic recommendations but feels the specifics that you've laid out don't work for them? What would you hope that teacher's next step would be?

JR: I would hope that they wouldn't just say that our list won't do, but that they would start hunting and get together with their colleagues and figure out what does work for them. I would be interested in knowing how they know it won't work. Have they actually tried teaching this topic without using this whole array of terms? When this hypothetical teacher makes a statement that it wouldn't work for him or her, part of my response to that statement would be "did you actually try?"

AA: I would hate to see a teacher or a group of teachers sit around and decide what terms they like without them getting into thinking about how that serves the whole pattern of what they're teaching. You should not just decide to leave out or not to leave out something without thinking about where it leads and what it contributes to.



JR: I think having educators get together to decide which terms to eliminate is reasonable if everyone agrees with the principle that you'll have to eliminate some things, what the candidates are, and what are the rationale and criteria for limiting. Before we conclude our discussion, I would like to point out that a common defense of excess material now taught in science courses is "you will need it later." I believe the truth is you'll rarely run into it again. So we have to be a little careful about using that as an excuse for not eliminating excess material.

About Project 2061

Project 2061 of the American Association for the Advancement of Science has developed a set of reform tools to help educators meet science literacy goals.

Science for All Americans (OUP, $14.95) describes what every citizen needs to know in science, mathematics, and technology. ***Benchmarks for Science Literacy*** (OUP, $26.50) presents specific learning goals in science, mathematics, and technology for the end of grades 2, 5, 8, and 12. Both books are available in Spanish (OUP-Mexico). ***Resources for Science Literacy: Professional Development*** (OUP, $49.95) provides educators with valuable materials to improve their own knowledge and skills. ***Blueprints for Reform*** (OUP, $17.95) outlines changes needed in a dozen areas of the education system to improve learning in science, mathematics, and technology. ***Dialogue on Early Childhood Science, Mathematics, and Technology Education*** (AAAS, $12.95) discusses the latest findings on teaching these subjects to preschool children. ***Middle Grades Mathematics Textbooks: A Benchmarks-Based Evaluation*** (AAAS, $89) presents the results of Project 2061's analysis of both widely used and newly developed middle school mathematics texts. ***Designs for Science Literacy*** and ***Designs on Disk*** (OUP $32.50) provide a theoretical framework and practical guidelines for designing coherent K-12 curricula.

Project 2061 Professional Development Programs provide custom-tailored workshops on understanding benchmarks and standards and aligning curriculum and assessment to them.

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To order Project 2061 products call: Oxford University Press (OUP) - 1-800-451-7556; OUP-Mexico - 011-52-5-592-5600, ext. 166; AAAS Distribution Center - 1-800-222-7809.

Sampling Project 2061's Professional Development Programs

Starting this fall, teachers, administrators, and curriculum developers up and down the East Coast will have an opportunity to sample Project 2061's Professional Development Programs. These "open enrollment" sessions will provide learning experiences that challenge participants' ideas about teaching and learning with new information and skills, and promote reflection on their current professional practice. Scheduled to be held in Springfield, MA, Pittsburgh, Philadelphia, Baltimore, Richmond, Atlanta, and Miami, the workshops will enable educators to work with Project 2061's tools and procedures to clarify the intent of the national, state, and district standards they are responsible for implementing. Participants will then explore the changes in curriculum and instruction that alignment to these standards demands.

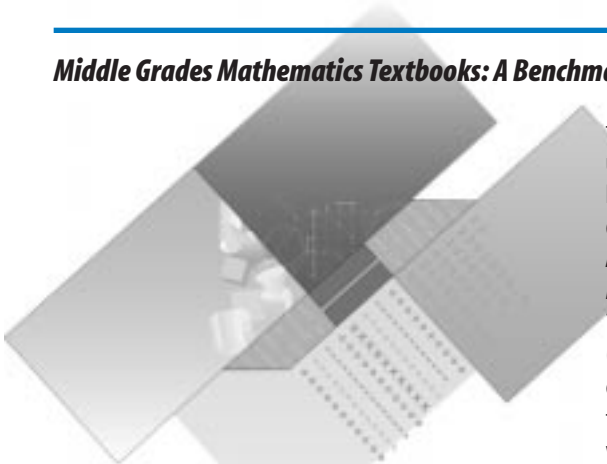
"With so many professional development programs out there, it's hard for educators to know which training will best fit their needs and truly make a difference in their classroom practice," states Mary Ann Brearton, program manager for Project 2061 Professional Development Programs. "In these workshops, participants will be engaged in a range of learning experiences focused on implementing standards-based programs. They will discuss the usefulness of what they are learning and decide how these new ideas and skills can be immediately transferred and practiced. They will also consider how our tools and training can help their school systems and districts reach goals for reform."

During the three-day sessions, participants will explore the idea that learning is not necessarily an outcome of teaching. They will look at the extent of science illiteracy in the United States and why reform in science education is needed. To develop a vision of what instruction for science literacy should be like, participants will study model science and mathematics lessons and see how these demonstrate effective principles of teaching and learning. They will also learn about Project 2061's curriculum-materials analysis procedure and how it can be used to select texts and other curriculum materials, revise lessons, and expand their repertoire of research-based instructional strategies.

Using Project 2061's newest tools, *Designs for Science Literacy* and *Atlas of Science Literacy*, participants will explore how to design instruction, from individual lessons to coherent curricula, and how to use strand maps to explore developmental progression of K-12 learning goals and connections among them. They will analyze assessments, explore the use of trade books in increasing instructional effectiveness, and examine "big picture" issues highlighting parts of the education system that need to change to bring about science, mathematics, and technology literacy for all students.

Districts are encouraged to send teams of educators, but individuals can also enroll. For more information about dates, times, and enrollment, call 1-888-PDP-2061, e-mail pdp2061@aaas.org, or visit www.pdp2061.org.

Middle Grades Mathematics Textbooks: A Benchmarks-Based Evaluation



Details and supporting documentation of Project 2061's rigorous analysis of middle grades math textbooks are now available in print and CD-ROM formats. The evaluation, first released in January 1999, rated several newer mathematics textbooks as excellent teaching tools, while several widely used texts were rated unsatisfactory. The findings have been helping textbook adoption committees in states and school districts around the country make more informed decisions. *Middle Grades Mathematics Textbooks: A Benchmarks-Based Evaluation* can be ordered from AAAS by calling 1-800-222-7809 or visiting www.project2061.org. The price is $89 (includes book and CD-ROM; $71 for orders of 10 or more copies). The publication contains an overall comparison of the textbooks analyzed, an overview of how and why the analysis was conducted, a description of Project 2061's analysis procedure and the cognitive research behind it, and summary reports on each text. The accompanying CD-ROM contains all the evaluation data and allows educators to delve deeper into the analysis findings and compare sets of data side-by-side.

Director's Notes

Form and Substance

Nobel prize-winning physicist Richard Feynman told a wonderful story about a tribal group in the Philippines who lived near a temporary American airfield during WWII. They were so impressed with the cargo being brought in by the planes that after troops abandoned the field, they built fires where the runway lights had been, constructed a bamboo control tower complete with a bamboo headset and stick antennas. As far as they could tell, they did everything that the GI's had done, but the planes never arrived.

In a similar example of form without substance, a major publisher includes a "self-analysis" in their new middle school science series purporting to use the Project 2061 evaluation tool. They claim that the books fare well in every criterion. But, there were no standards or benchmarks chosen as the basis of the analysis so there was no content evaluation. The instructional analysis as presented was in a nice form, but on closer examination the evidence had little to do with the criteria—and of course, nothing to do with the content. While we were pleased that the publishers had paid attention to our work, like the Philippines tribal group, they had merely recreated the form of a Project 2061 textbook analysis, but none of the substance.

A wonderful little book

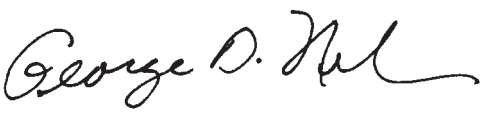
Millions and millions of dollars are being spent every year on textbooks with only the slightest attention to the question "Will students learn from this book?" Harriet Tyson-Bernstein's wonderful little book from the Council for Basic Education called *America's Textbook Fiasco, A Conspiracy of Good Intentions* (1988) lays out the problem as well I've ever seen it.

> "Textbooks, for better or worse, dominate what students learn. They set the curriculum, and often the facts learned, in most subjects. For many students, textbooks are their first and sometimes only early exposure to books and to reading. The public regards textbooks as authoritative, accurate, and necessary. And teachers rely on them to organize lessons and structure subject matter. But the current system of textbook adoption has filled our schools with Trojan horses—glossily-covered blocks of paper whose words emerge to deaden the minds of our nation's youth, and make them enemies of learning. . . altering the system of textbook adoption and consequently the quality of textbooks requires not money, but enlightened political will."

Bad news and good news

The bad news is that little has happened in the last twelve years to change this message. The good news is that Project 2061's independent evaluations of textbooks are beginning to "enlighten political will" and impact the textbook market. Our curriculum analysis tool is being used to develop new materials focused on student learning. Our professional development programs are helping a small and growing number of schools build the infrastructure and leadership necessary for making good decisions.

Progress is being made, but we will all have to work long and hard before we can say that all the books being used to teach our children are excellent. Meanwhile, we must avoid taking the short cuts that make us look good only on the surface. Only by combining form and substance in all that we do can we hope to improve textbooks and achieve meaningful improvement in science, mathematics, and technology education.



George D. Nelson
Director

Project 2061's independent evaluations of textbooks are beginning to 'enlighten political will' and impact the market.

FYI

Introducing . . .

Project 2061 is pleased to welcome new secretary **Clanni Knighten**. Her previous experience includes working as a loan officer and internal auditor for Magna Bank and Market Street Mortgage Companies in Chicago. The Project also welcomes writer **Jonah Ben-Joseph**, who most recently worked on a special project for the George Washington University School of Engineering and Applied Science.

Project 2061 Represented at Association of American Publishers Meeting

At the annual meeting of the Association of American Publishers School Division in Orlando, Florida, Project 2061 Director George Nelson spoke about Project 2061's math and science textbook evaluations as part of a panel discussion on "Teaching Science and Math in the Next Millennium." His oped "Learning Math: More Research, Less Rhetoric" appeared in the *Orlando Sentinel* during the conference.

Assessment Workshops

Project 2061's effort to develop new strategies and tools for evaluating the alignment of K-12 assessments in science and mathematics to national and state standards and benchmarks is well underway. The project has conducted two workshops to test and refine its assessment analysis procedure: one with a group of renowned mathematicians and another with 20 science education experts. Based on findings from these workshops, staff members are currently rewriting Project 2061's assessment analysis procedure and analysis work may begin as early as June. Project 2061's assessment project is supported by a grant from the National Science Foundation.

Project 2061 Web Site Now Available in Spanish

Educators, policymakers, and parents can now access a Spanish version of Project 2061's popular Web site at www.project2061.org/espanol. Two of the Project's most influential publications, *Science for All Americans* and *Benchmarks for Science Literacy*, are available in Spanish on the site as well as portions of *Blueprints for Reform,* information on Project 2061 Professional Development Programs, and links to Project 2061's main site.

New Book on Inquiry from AAAS

Inquiring into Inquiry Learning and Teaching in Science presents a comprehensive look at inquiry in different educational settings. Editors Jim Minstrell and Emily H. van Zee and more than 40 other contributors—K-12 teachers, researchers, scientists, and teacher educators—offer insights from years of successful experience studying and practicing inquiry in K-12 and university classrooms and guiding students and teachers in the application and utilization of inquiry. To order, contact Betty Calinger at (202) 326-6629 or bcalinge@aaas.org.

2061 *today*

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