Chapter 6

ABOUT STANDARDS

Overview

In Chapter 3, "Activities," we have listed standards references for each activity. This type of listing is now found in most curriculum materials, in order to demonstrate that the activities "meet standards." In a way, these standards references miss the point, because the national standards are not meant to be read in this way. Meeting standards is not really about checking off items from a list. Each of the major standards documents is a coherent, comprehensive call for systematic change in education.

This chapter shows how ***Stuff That Works!*** is consistent with national standards at a very fundamental level. We will look in detail at the following documents:

- *Standards for Technological Literacy: Content for the Study of Technology* (International Technology Education Association, 2000);
- *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993);
- *National Science Education Standards* (National Research Council, 1996);
- *Standards and Principles for School Mathematics* (National Council of Teachers of Mathematics, 2000);
- *Standards for the English Language Arts* (National Council of Teachers of English & International Reading Association, 1996); and
- *Curriculum Standards for the Social Studies* (National Council for the Social Studies, 1994).

Most of these standards are now widely accepted as the basis for state and local curriculum frameworks. The first document on the list is included because it is the only national standard focused primarily on technology. *The New Standards Performance Standards* (National Center on Education and the Economy, 1997) is not included because it is based almost entirely on the *Benchmarks, National Science Education Standards,* the original NCTM Math *Standards* (1989), and the *Standards for the English Language Arts.*

Although they deal with very different disciplines, these major national standards documents have many remarkable similarities:

- They are aimed at *all* students, not only those who are college-bound.
- Using terms like "literacy" and "informed citizen," they argue that education should prepare students to understand current issues and participate in contemporary society.
- They recommend that school knowledge be developed for its use in solving real problems rather than as material "needed" for passing a test. They strongly endorse curriculum projects that arise from students' own ideas, experiences, and interests.
- They focus on the "big ideas" of their disciplines as opposed to memorization of isolated facts or training in narrowly defined skills. In other words, fewer concepts should be dealt with in greater depth. As the *National Science Education Standards* express it, "Coverage of great amounts of trivial, unconnected information must be eliminated from the curriculum". (NRC, 1996, p. 213)

- The standards reject standardized tests as the sole or even the major form of assessment. Traditional exams measure only what is easy to measure rather than what is most important. "While many teachers wish to gauge their students' learning using performance-based assessment, they find that preparing students for machine-scored tests—which often focus on isolated skills rather than contextualized learning—diverts valuable classroom time away from actual performance." (NCTE/IRA, 1996, p. 7) The standards promote authentic assessment measures, which require students to apply knowledge and reasoning "to situations similar to those they will encounter outside the classroom." (NRC, 1996, p. 78) Furthermore, assessment should become "a routine part of the ongoing classroom activity rather than an interruption" and it should consist of "a convergence of evidence from different sources." (NCTM, 2000, p. 23)
- They highlight the roles of quantitative thinking, as well as oral and written communication, in learning any subject, and they emphasize the interdisciplinary character of knowledge.
- They view learning as an active process requiring student engagement with the material and subject to frequent reflection and evaluation by both teacher and learner.
- They urge teachers to "display and demand respect for the diverse ideas, skills and experiences of all students," and to "enable students to have a significant voice in decisions about the content and context of their work." (NRC, 1996, p. 46)

The ***Stuff That Works!*** materials are based on these ideas and provide extensive guidance on how to implement them in the classroom. We begin our study of technology with students' own ideas and experiences, address problems that are of importance to them, develop "big ideas" through active engagement in analysis and design, and draw connections among the disciplines. While the standards are clear about the principles, they do not provide many practical classroom examples. ***Stuff That Works!*** fills this gap.

Where the Standards Came From

Historically speaking, the current tilt towards national curriculum standards is a dramatic departure from a long tradition of local control of education. How did national standards manage to become the order of the day? In the late 1970's, the country was in a serious recession, driven partly by economic competition from Europe and Japan. In 1983, the National Commission on Educational Excellence (NCEE) published an influential report, *A Nation at Risk,* which painted a depressing picture of low achievement among the country's students. The report warned of further economic consequences should these problems continue to be ignored, and advocated national curriculum standards for all students. Adding to these arguments were pressures from textbook publishers, who felt that national standards would make state and local adoption processes more predictable.

Around the same time, several of the major professional organizations decided to provide leadership in setting standards. The pioneering organizations were the National Council of Teachers of Mathematics (NCTM) and the American Association for the Advancement of Science (AAAS), whose efforts culminated in the publication of major documents in 1989. In the same year, the National Governors' Association and the first Bush Administration both endorsed the concept of establishing national educational goals. The NCTM was deeply concerned about the issues raised by *A Nation at Risk* and was convinced that professional educators needed to take the initiative in setting a new educational agenda. Otherwise, the reform of curriculum would rest in the hands of textbook and test publishers, legislatures, and local districts.

Both the NCTM and the AAAS standards projects began with a similar basic position about pedagogy. Influenced by research about what children actually know, they recognized the disturbing fact that "learning is not necessarily an outcome of teaching." (AAAS, 1989, p. 145) In contrast with traditional approaches to education, which emphasize memorization and drill, the new national standards promote strategies for active learning. A related theme of the early standards efforts was that the schools should teach fewer topics in order that "students end up with richer insights and deeper understandings than they could hope to gain from a superficial exposure to more topics…" (p. 20)

Meeting standards requires a major investment of time and resources. Some of the necessary ingredients include new curriculum ideas and materials, professional development opportunities, new assessment methods, and smaller class sizes. The *National Science Education Standards* are the most explicit in identifying the conditions necessary—at the classroom, school, district, and larger political levels—for standards to be meaningful. The authors state, "Students could not achieve standards in most of today's schools." (NRC, 1996, p. 13) More money might not even be the hardest part. Standards-based reforms also require understanding and commitment from everyone connected with the educational system, starting at the top.

The history of standards may contain clues about their future. Standards imply neither textbook-based instruction nor standardized tests. Standards arose because traditional text- and test-based education had failed to result in the learning of basic concepts by the vast majority of students. Ironically, there are many textbook and test purveyors who market their products under the slogan "standards-based." Standards could easily become discredited if those who claim their imprimatur ignore their basic message.

What the Standards Actually Mean

Standards are commonly read as lists of goals to be achieved through an activity or a curriculum. This approach is reflected in the lists of standards references and cross-references that appear in most curriculum materials, as evidence that an activity or curriculum "meets standards."

Presenting lists of outcomes reflects a narrow reading of standards, which can be very misleading. These lists suggest that "meeting standards" is simply a matter of getting students to repeat something like the statements found in the standards documents, such as the one quoted above.

In fact, the standards are much richer and more complex than these lists imply. Many of the standards do not even specify the knowledge that students should acquire, but deal rather with ways of using that knowledge. Here is an example from *Benchmarks for Science Literacy:*

> "By the end of fifth grade, students should be able to write instructions that students can follow in carrying out a procedure." (p. 296)

This standard talks about something students should be *able to do,* rather than what they should *know.* The NCTM document, *Principles and Standards for School Mathematics* (2000), unlike the earlier one (NCTM, 1989), explicitly separates "Content Standards" from "Process Standards." The Content Standards outline what students should learn, while the Process Standards cite ways of acquiring and expressing the content knowledge. The Process Standards include problem solving, communication, and representation. The *Benchmarks* example just cited above is another example of a process standard. Similarly, in the English Language Arts (ELA) document (NCTE/IRA, 1996), all twelve standards use verbs to express what students should *do,* as opposed to what they should *know.* Any reading of standards that focuses only on content knowledge is missing a central theme of all of the major documents.

There is also material in the standards that qualifies neither as content nor as process. Here is an example from the Benchmarks chapter called "Values and Attitudes":

> "By the end of fifth grade, students should raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out." (p. 285)

This standard asks for more than a specific piece of knowledge, ability, or skill. It calls for a way of looking at the world, a general conceptual framework, that transcends the boundaries of disciplines. Similarly, the "Connections" standard in the new NCTM document underscores the need for students to ...

> "... Recognize and apply mathematics in contexts outside of mathematics." (NCTM, 2000, p. 65)

These are examples of broad curriculum principles that cut across the more specific content and process standards. These standards are not met by implementing a particular activity or by teaching one or another lesson. They require an imaginative search for opportunities based on a reshaping of goals for the entire curriculum.

In general, the standards documents are at least as much about general principles as about particular skills and knowledge bases. The *Standards for Technological Literacy,* the *Benchmarks,* and the *National Science Education Standards* each identifies some big ideas that recur frequently and provide explanatory power throughout science and technology. "Systems" and "modeling" are concepts that appear in all three documents. The presence of such unifying ideas suggests that the individual standards references should not be isolated from one another. They should rather be seen as parts of a whole, reflecting a few basic common themes.

What Use Are Standards?

Increasingly, teachers are being held accountable for "teaching to standards." These demands are added to such other burdens as paperwork, test schedules, classroom interruptions, inadequate space and budgets, arbitrary changes in class roster, etc. In the view of many teachers, children and their education are routinely placed dead last on the priority list of school officials. Understandably, teachers may resent or even resist calls to "meet standards" or demonstrate that their curricula are "standards-bearing." It is not surprising that many teachers cynically view the standards movement as "another new thing that will eventually blow over."

The push to "meet standards" is often based on a misreading of standards as lists of topics to be "covered" or new tests to be administered. It is not hard to imagine where this misinterpretation might lead. If the proof of standards is that students will pass tests, and students fail them nevertheless, then the standards themselves may eventually be discarded. Paradoxically, the prediction that "this, too, shall pass" would then come true, not because the standards failed, but because they were never understood nor followed.

Standards are intended to demolish timeworn practices in education. Some of these practices place the teacher at the center of the classroom but reduce her or him to a cog in the machinery of the school and the district, with the primary responsibility of preparing students for tests. The standards documents recognize the need to regard teachers as professionals, students as active, independent learners, and tests as inadequate methods of assessing the full range of learning.

Within broad frameworks, the standards urge teachers to use their judgment in tailoring the curriculum to students' needs and interests. The NRC Science Standards, for example, call for "teachers [to be] empowered to make the decisions essential for effective learning." (1996, p. 2) Neither teachers nor administrators should interpret standards as mechanisms for tightening control over what teachers and students do. While they are very clear about the goals of education, the standards are less specific about how to meet them. Innovative curriculum efforts such as ***Stuff That Works!*** fit very well within the overall scheme of standards.

Teachers who have tried to implement ***Stuff That Works!*** activities in their classrooms have often come away with a positive feeling about them. The following comments are typical:

- *The strengths of this unit are the opportunity to group students, work on communication skills, problem solve … and plan real life tests. I have watched my students go from asking simple yes/no questions to thinking and planning careful, thoughtful active questions. The students began to see each other as people with answers... I was no longer the expert with all the answers.*
- *I must begin by telling you that I found this particular guide to be so much fun and the students demonstrated so much energy and interest in this area... I was able to engage them in the activities easily... The activities were very educational and provided so much vital information that helped students connect what is being taught to them in math to real life situations, e.g., graphing behavior and using tallies to record information. For my [special education] students, I found this gave them self confidence...*
- *I read the entire guide from front to back... Although the main idea of the unit is not specifically a large focus of instruction in our fourth grade curriculum, I recognized the power behind the ideas and activities and knew that this unit would promote collaboration, problem solving and communication... Overall, I think my students loved this unit and felt enormously successful after we finished...*
- *My most important goal for students is that they feel good about themselves and realize what they can do. I liked these activities, because they had these results.*

The standards are intended to promote just these sorts of outcomes. When a teacher has a "gut feeling" that something is working well, there is usually some basis to this feeling. As the NRC Science Standards state, "outstanding things happen in science classrooms today… because extraordinary teachers do what needs to be done *despite conventional practice* [emphasis added]." (1996, p. 12) Unfortunately, even an extraordinary teacher may not find support from traditional administrators, who complain that the classroom is too noisy or messy, or that somebody's guidelines are not being followed. Under these circumstances, standards can be very useful. It is usually easy to see how valuable innovations fit into a national framework of education reform that is also endorsed by state- and district-level authorities. Standards can be used to justify and enhance innovative educational programs whose value is already self-evident to teachers and students.

What the Standards Really Say

In order to justify work as meeting standards, it is necessary to know what the standards really say. In the remainder of this chapter, we summarize each of the six major standards documents listed at the beginning of the chapter, and show how the ***Stuff That Works!*** ideas are consistent with these standards. We provide some historical background for each of the standards, and look at the overall intent and structure before relating them to the ***Stuff That Works!*** materials. These sections should be used only as they are needed. For example, if you would like to use some of the ideas from this Guide, and are also required to meet the *National Science Education Standards,* then that section could be useful to you in helping you justify your work.

Standards for Technological Literacy: Content for the Study of Technology

In April 2000, the International Technology Education Association (ITEA) unveiled the *Standards for Technological Literacy,* commonly known as the *Technology Content Standards,* after extensive reviews and revisions by the National Research Council (NRC) and the National Academy of Engineering (NAE). In its general outlines, the new standards are based on a previous position paper, *Technology for All Americans* (ITEA, 1996). The latter document defined the notion of "technological literacy" and promoted its development as the goal of technology education.

A technologically literate person is one who understands "what technology is, how it is created, and how it shapes society, and in turn is shaped by society." (ITEA, 2000, p. 9) According to the *Standards,* familiarity with these principles is important not only for those who would pursue technical careers, but for all other students as well. They will need to know about technology in order to be thoughtful practitioners in most fields, such as medicine, journalism, business, agriculture, and education. On a more general level, technological literacy is a requirement for participation in society as an intelligent consumer and an informed citizen.

Given the importance of being technologically literate, it is ironic that technology barely exists as a school subject in the U.S., and is particularly hard to find at the elementary level. In a curriculum overwhelmingly focused on standardized tests, there seems to be little room for a new subject such as technology. To make matters worse, there is considerable confusion over what the term technology even means. Many in education still equate it with "computers." The *Standards* advocate for technology education based on a broad definition of "technology," which is "how humans modify the world around them to meet their needs and wants, or to solve practical problems." (p. 22)

The *Technology Content Standards* describe three aspects of developing technological literacy: learning about technology, learning to do technology, and technology as a theme for curriculum integration (pp. 4-9). To learn about technology, students need to develop knowledge not only about specific technologies (Standards 14 – 20), but also about the nature of technology in general (Standards 1 – 3), including its core concepts: **systems, resources, requirements, trade-offs, processes,** and **controls.** Resources include **materials, information,** and **energy,** while **modeling** and **design** are fundamental examples of processes (p. 33). Students learn to "do" technology by engaging in a variety of technological processes, such as **troubleshooting, research, invention, problem solving, use and maintenance, assessment** of technological impact, and, of course, **design** (Standards 8 – 13). Technology has obvious and natural connections with other areas of the curriculum, including not only math and science, but also language arts, social studies, and the visual arts.

According to the *Technology Content Standards,* design is "the core problem-solving process [of technology]. It is as fundamental to technology as inquiry is to science and reading is to language arts." (p. 91) The importance of design is underlined by the statement, a little further on, that "students in grades K-2 should learn that everyone can design solutions to a problem." (p. 93) Several pages later, the *Standards* suggest that young children's experiences in design should focus on "problems that relate to their individual lives, including their interactions with family and school environments." (p.100) However, the *Technology Content Standards* offer little if any guidance on how to identify such problems. The vignette provided on the following page of the *Standards,* "Can you Help Mike Mulligan?", is based on a literature connection rather than on problems that arise from children's lives.

Designed Environments: Places, Practices, and Plans provides numerous examples of how younger and older children can become involved in solving problems from their own environment. They brainstorm about problems and issues that concern them, develop solutions in collaborative groups, and evaluate them. The problems range from finding a way to limit classroom interruptions to redesigning lunch schedules and lunchroom furniture to reduce waiting times, litter, and confusion in the cafeteria. By solving problems such as these, children develop an understanding that they themselves can design solutions to a problem.

Where does technology education "fit" in the existing curriculum? The *Technology Standards* address this problem by claiming that technology can enhance other disciplines: "Perhaps the most surprising message of the *Technology Content Standards* ... is the role technological studies can play in students' learning of other subjects." (p. 6) We support this claim in the following sections, which draw the connections between ***Stuff That Works!*** and national standards in science, math, English language arts, and social studies.

Benchmarks for Science Literacy

There are two primary standards documents for science education: The American Association for the Advancement of Science (AAAS) *Benchmarks for Science Literacy* (1993) and the National Research Council (NRC) *National Science Education Standards* (1996). Unlike the *National Science Education Standards,* the *Benchmarks* provide explicit guidance for math, technology, and social science education, as well as for science. The *Benchmarks* draw heavily on a previous AAAS report, *Science for All Americans* (1989), which is a statement of goals and general principles rather than a set of standards. *Benchmarks* recast the general principles of *Science for All Americans* (SFAA) as minimum performance objectives at each grade level.

The performance standards in *Benchmarks* are divided among 12 chapters. These include three generic chapters regarding the goals and methods of science, math and technology; six chapters providing major content objectives for the physical, life, and social sciences; technology and mathematics; and three generic chapters dealing with the history of science, "common themes," and "habits of mind." The last four chapters of *Benchmarks* provide supporting material, such as a glossary of terms and references to relevant research.

Recognizing that standards are necessary but not sufficient for education reform, the AAAS has also developed some supplementary documents to support the process of curriculum change. These include *Resources for Science Literacy: Professional Development* (1997), which suggests reading materials for teachers, presents outlines of relevant teacher education courses, and provides comparisons between the *Benchmarks,* the Math Standards, the Science Standards, and the Social Studies Standards. A subsequent publication, *Blueprints for Science Reform* (1998) offers guidance for changing the education infrastructure to support science, math, and technology education reform. The recommendations in

Blueprints are directed towards administrators, policy makers, parent and community groups, researchers, teacher educators, and industry groups. A subsequent AAAS document, *Designs for Science Literacy* (2001), provides examples of curriculum initiatives that are based on standards.

The *Benchmarks* present a compelling argument for technology education. The authors present the current situation in stark terms: "In the United States, unlike in most developed countries in the world, technology as a subject has largely been ignored in the schools." (p. 41) Then they point out the importance of technology in children's lives, its omission from the curriculum notwithstanding: "Young children are veteran technology users by the time they enter school.... [They] are also natural explorers and inventors, and they like to make things." (p. 44) To resolve this contradiction, "School should give students many opportunities to examine the properties of materials, to use tools, and to design and build things." (p. 44)

Like the Technology *Standards,* the *Benchmarks* identify **design** as a key process of technology and advocate strongly for first-hand experience in this area. "Perhaps the best way to become familiar with the nature of engineering and design is to do some." (p. 48) As children become engaged in design, they "begin to enjoy challenges that require them to clarify a problem, generate criteria for an acceptable solution, try one out, and then make adjustments or start over again with a newly proposed solution." (p. 49) These statements strongly support the basic approach of ***Stuff That Works!,*** which is to engage children in analysis and design activities based on the technologies already familiar to them. Like ***Stuff That Works!,*** the *Benchmarks* also recognize the back-and-forth nature of design processes, which rarely proceed in a linear, predictable sequence from beginning to end.

In the chapter "Common Themes," *Benchmarks* identifies several "big ideas" that recur frequently in science, mathematics, and technology, and are powerful tools for explanation and design. One of these themes, **systems**, is at least as important in technology as in science, and is squarely addressed by work with social systems found in *Designed Environments: Places, Practices, and Plans.* The section on systems begins, "One of the essential components of higher-order thinking is the ability to think about a whole in terms of the sum of its parts and, alternatively, about parts in terms of how they relate to one another and to the whole." (p. 262) The section goes on to point out that these ideas are difficult, and learned only through studying progressively more complex examples. The social systems analyzed and designed in *Designed Environments: Places, Practices, and Plans* represent such complex examples. A major theme in the chapter on "The Nature of Technology" is Design and Systems. "Perhaps the best way to become familiar with the nature of engineering and design is to do some. By participating in such activities, students should learn how to analyze situations and gather relevant information, define problems, generate and evaluate creative ideas, develop their ideas into tangible solutions, and assess and improve their solutions." (p. 48)

Processes similar to those advocated above characterize most of the activities in *Designed Environments: Places, Practices, and Plans.* For example, in "Classroom Procedures" the teacher helps students to identify a classroom problem, usually resulting from procedures that are not working well. The students then collect data to further define the nature and extent of the problem. They describe what an improved situation would look like, develop plans for a better classroom procedure, then select the new procedure they think is best. After it has been in place for a while, the new procedure is assessed.

Through a design process such as that seen in "Classroom Procedures" students begin to see the interconnectedness that typifies a social system: when procedures are changed, different results follow; different enforcers result in differences in the extent to which procedures are followed.

In its chapter on "Human Society," *Benchmarks* recommends that children also learn about social structures first-hand: "Students can begin by finding out what the rules are in different classrooms and families, observing how children respond to the rules and recording their findings." (p. 154) A similar suggestion appears in the *National Standards for Social Studies Teachers:* "Teachers of the early grades can introduce learners to civic ideals and practices through activities such as involving them in the establishment of classroom rules and expectations." (NCSS, 1997, p. 24) Analysis and redesign of classroom rules are a major component of *Designed Environments: Places, Practices, and Plans.*

As they test alternative designs, whether for cafeterias, furniture arrangements, or classroom procedures, students find it necessary to collect data and make judgments based on evidence, not opinion. These analysis and design activities lead to important "habits of mind": "By the end of second grade, students should raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out." (p. 285) By comparing one another's designs and using data to assess them, they develop "critical response skills": "By the end of second grade, students should ask 'How do you know?' in appropriate situations and attempt reasonable answers when others ask them the same question." (p. 298)

The National Science Education Standards

In 1991, the National Science Teachers Association asked the National Research Council to develop a set of national science education standards. These standards were intended to complement the *Benchmarks,* which include math, technology, and social studies as well as natural science. The National Research Council (NRC) includes the National Academy of Sciences, which is composed of the most highly regarded scientists in the country. Over the course of the next five years, the NRC involved thousands of scientists, educators, and engineers in an extensive process of creating and reviewing drafts of the new science standards. The results were published in 1996 as the *National Science Education Standards* (NSES).

Who is the audience for standards? The conventional view is that standards outline what students should know and be able to do, and that teachers are accountable for assuring that their students meet these guidelines. The NSES take a much broader approach, looking at the whole range of systemic changes needed to reform science education. The document is organized into six sets of standards. Only one of the six, the "Science Content Standards," talks directly about what children should learn through science education. The other five address other components of the education infrastructure, including classroom environments, teaching methods, assessment, professional development, administrative support at the school and district levels, and policy at the local, state, and national levels.

Collectively, these standards outline the roles of a large group of people on whom science education depends: teachers, teacher educators, staff developers, curriculum developers, designers of assessments, administrators, superintendents, school board members, politicians, informed citizens, and leaders of professional associations. If an administrator or school board member were to ask a teacher, "What are you doing to address the *National Science Education Standards?"* the teacher would be fully justified in responding, "What are you doing to meet them?"

One message that recurs frequently in the NSES is that teachers must be regarded as professionals, with a vital stake in the improvement of science education and an active role "in the ongoing planning and development of the school science program." (p. 50) More specifically, they should "participate in decisions concerning the allocation of time and other resources to the science program." (p. 51) The *Standards* explicitly reject the reduction of teachers to technicians or functionaries who carry out somebody else's directives. "Teachers must be acknowledged and treated as professionals whose work requires understanding and ability." The organization of schools must change too: "School leaders must structure and sustain suitable support systems for the work that teachers do." (p. 223)

Teachers should also play a major role in deciding and/or designing the science curriculum. The *Standards* call for teachers to "select science content and adapt and design curricula to meet the needs, interests, abilities and experiences of students." Although teachers set the curriculum initially, they should remain flexible: "Teaching for understanding requires responsiveness to students, so activities and strategies are continuously adapted and refined to address topics arising from student inquiries and experiences, as well as school, community and national events." (p. 30) Not only teachers, but also students, should play a major role in curriculum planning. The Teaching Standards make this point explicit: "Teachers [should] give students the opportunity to participate in setting goals, planning activities, assessing work and designing the environment." (p. 50)

More specifically, Content Standard E, "Science and Technology." strongly supports the approach of ***Stuff That Works!*** Although this standard focuses on the study of mechanical systems such as zippers or can openers, it also recognizes the value of the types of activities found in *Designed Environments: Places, Practices, and Plans:* "It is important also to include design problems that require application of ideas, use of communication, and implementation of procedures—for instance improving hall traffic at lunch and cleaning the classroom after scientific investigations." (p. 137)

The *Science Standards* do not make the distinction between design and inquiry as sharply as do the *Technology Standards:* "Children in grades K-4 understand and can carry out design activities earlier than they can inquiry activities, but they cannot easily tell the difference between the two, nor is it important whether they can." (p.135) Thus, many of the abilities and concepts needed to meet the standard "Science as Inquiry" are also developed through design. These include: "Ask a question about objects… in the environment"; "plan and conduct a simple investigation"; "employ simple equipment and tools to gather data"; and "communicate investigations or explanations." (p. 122)

A central theme of *Designed Environments: Places, Practices, and Plans* is that teachers should involve children in both analyzing and designing aspects of the classroom environment, although these tasks have traditionally been reserved for teachers. These aspects include the physical arrangement of the space, as well as the schedules followed, and the rules and practices that govern behavior. The "Teaching Standards" section of the NSES makes the same point:

> "As part of challenging students to take responsibility for their learning, teachers [should] involve them in the design and management of the learning environment. Even the youngest students can and should participate in discussions and decisions about using time and space for work." (p. 45)

Principles and Standards for School Mathematics

The first of the major standards documents, *Curriculum and Evaluation Standards for School Mathematics,* was published in 1989 by the National Council of Teachers of Mathematics (NCTM). Additional standards for teaching and assessment were published in 1991 and 1995, respectively. In 2000, the NCTM released a new document, *Principles and Standards for School Mathematics,* intended to update and consolidate the classroom-related portions of the three previous documents. Some of the major features of the new volume, different from the prior version, are the addition of the Principles, the division of the standards into the categories "Content" and "Process," and the inclusion of a new process standard called "Representation."

The new NCTM document acknowledges the limitations of educational standards: "Sometimes the changes made in the name of standards have been superficial or incomplete… Efforts to move in the direction of the original NCTM Standards are by no means fully developed or firmly in place." (pp. 5-6) In spite of this candid assessment, the authors remain optimistic about the future impact of standards. Their goal is to provide a common framework for curriculum developers and teachers nationwide. If all schools follow the same standards, then teachers will be able to assume that "students will reach certain levels of conceptual understanding and procedural fluency by certain points in the curriculum." (p. 7)

The NCTM *Principles and Standards* begin by presenting the six sets of principles, which are the underlying assumptions for the standards. Some of these principles are common to the other standards documents: that there should be high expectations of all students, that the goal of learning is deep understanding, and that assessment should be integrated with curriculum. Other principles underscore the need to learn from cognitive research. More than in any other field, there has been extensive research into how students learn mathematics, and this research base is reflected in the *Principles*. For example, the "Curriculum Principle" calls for coherent sets of lessons, focused collectively on one "big idea." Similarly, the "Teaching Principle" specifies that teachers must be aware of students' cognitive development. The "Learning Principle" cites research on how learning can be most effective.

The standards themselves are organized into two categories: Content Standards and Process Standards. The former describe what students should learn, in the areas of Number and Operations, Algebra, Geometry, Measurement, and Data Analysis and Probability. The Process Standards discuss how students should acquire and make use of the content knowledge. The subcategories are Problem Solving, Reasoning and Proof, Communication, Connections, and Representation. Unlike the earlier NCTM document, the new version uses all the same standards across all of the grade levels, from K through 12. In this way, the NCTM is advocating for a carefully structured curriculum, which builds upon and extends a few fundamental ideas systematically across the grades. Readers may be surprised to find an Algebra Standard for grades K-2, or a Number and Operations Standard for grades 9-12.

Stuff That Works! units and activities offer rich opportunities for fulfilling a key ingredient of the NCTM standards: learning and using mathematics in context. The Process Standard called "Connections" makes it clear that mathematics should be learned by using it to solve problems arising from "other subject areas and disciplines" as well as from students' daily lives." (p. 66) ***Stuff That Works!*** fulfills this standard in two fundamental respects: it provides mathematics connections with another subject area, technology, and it uses artifacts and issues from everyday life as the source of material for study. The mathematics students learn is drawn from all of the Content Standards, as well as all of the Process Standards except for Reasoning and Proof.

Designed Environments: Places, Practices, and Plans involves students in identifying real problems in their own immediate environments and in designing and testing solutions to these problems. In the course of these activities, they have to decide what kind of data to collect, and how to analyze it, both in order to explore the problem and also to evaluate their solutions. This process of problem formulation, data collection, and analysis is advocated by the NCTM:

> "The Data Analysis and Probability Standard recommends that students formulate questions that can be answered using data and addresses what is involved in gathering and using data wisely. Students should learn how to collect data, organize their own or others' data, and display the data in graphs or charts that will be useful in answering their questions. This Standard also includes learning some methods for analyzing data and some ways for making inferences and conclusions from data." (p. 48)

In the context of *Designed Environments: Places, Practices, and Plans,* students have a powerful stake in learning these processes well, because the problems they are attempting to solve are *their* problems.

Standards for the English Language Arts

By 1991, it had become clear that standards would be produced for all of the major school subjects. Fearful that English language standards might be produced without a firm basis in research and practice, two major professional organizations requested Federal funding for their own standards effort. The following year, the Department of Education awarded a grant for this purpose to the Center for the Study of Reading at the University of Illinois, which agreed to work closely with the two organizations, the National Council of Teachers of English (NCTE) and the International Reading Association (IRA). This effort culminated in the 1996 publication of the *Standards for the English Language Arts* by the NCTE and IRA. These ELA Standards are now widely accepted for their clear, concise outline of English language education.

The ELA *Standards* adopt an unusually comprehensive view of "literacy," much broader in its scope than the traditional definition of "knowing how to read and write." (p. 4) Literacy also includes the ability to think critically, and encompasses oral and visual, as well as written communication. Recognizing that these forms of language "are often given limited attention in the curriculum," the *Standards* outline the variety of means used to convey messages in contemporary society:

> "Being literate in contemporary society means being active, critical, and creative users not only of print and spoken language, but also of the visual language of film and television, commercial and political advertising, photography, and more. Teaching students how to interpret and create visual texts such as illustrations, charts, graphs, electronic displays, photographs, film and video is another essential component of the English language arts curriculum." (pp. 5-6)

According to the ELA *Standards*, there are three major aspects to language learning: **content, purpose,** and **development.** Content standards address only *what* students should learn, but not why or how: "knowledge alone is of little value if one has no need to—or cannot—apply it." The *Standards* identify four purposes for learning and using language: "for obtaining and communicating information, for literary response and expression, for learning and reflection, and for problem solving and application." (p. 16) Purpose also figures prominently in the third dimension of language learning, development, which describes *how* students acquire this facility. "We learn language not simply for the sake of learning language; we learn it to make sense of the world around us and to communicate our understanding with others." (p. 19)

Of course, purpose and motivation vary from one situation to another. The authors of the *Standards* make this point, too, in their discussion of "context." "Perhaps the most obvious way in which language is social is that it almost always relates to others, either directly or indirectly: we speak to others, listen to others, write to others, read what others have written, make visual representations to others and interpret their visual representations." Language development proceeds through the practice of these communication skills with others: "We become participants in an increasing number of language groups that necessarily influence the ways in which we speak, write and represent." While language development is primarily social, there is an individual dimension as well: "All of us draw on our own sets of experiences and strategies as we use language to construct meaning from what we read, write, hear, say, observe, and represent." (p. 22)

How does this broad conception of literacy and its development relate to daily classroom practice? The authors recognize that the ELA *Standards* may be in conflict with the day-to-day demands placed on teachers. "They may be told they should respond to the need for reforms and innovations while at the same time being discouraged from making their instructional practices look too different from those of the past." Among those traditional practices are the use of standardized tests, "which often focus on isolated skills rather than contextualized learning." Prescribed texts and rigid lesson plans are further barriers to reform, because they tend to preclude "using materials that take advantage of students' interests and needs" and replace "authentic, open-ended learning experiences." (p. 7) Another problem is "the widespread practice of dividing the class day into separate periods [which] precludes integration among the English language arts and other subject areas." (p. 8) Taken seriously, these standards would lead to wholesale reorganization of most school experiences.

This introductory material sets the stage for the twelve content standards, which define "what students should know and be able to do in the English language arts." (p. 24) Although these are labeled "content" standards, "content cannot be separated from the purpose, development and context of language learning." (p. 24) In a variety of ways, the twelve standards emphasize the need to engage students in using language clearly, critically and creatively, as participants in "literacy communities." Within these communities, students sometimes participate as receivers of language—by interpreting graphics, reading and listening and—and sometimes as *creators*—by using visual language, writing, and speaking.

Some teachers have used the ***Stuff That Works!*** activities and units primarily to promote language literacy, rather than for their connections with math or science. Technology activities offer compelling reasons for children to communicate their ideas in written, spoken, and visual form. In early childhood and special education classrooms, teachers have used ***Stuff That Works!*** to help children overcome difficulties in reading and writing, because it provides natural and non-threatening entry points for written expression. In the upper elementary grades, ***Stuff That Works!*** activities offer rich opportunities for students to want to use language for social purposes. Several characteristics of ***Stuff That Works!*** contribute to its enormous potential for language learning and use:

- Every unit begins with an extensive group discussion of what terms mean, how they apply to particular examples, how to categorize things, and/or what problems are most important.
- The activities focus on artifacts and problems that engage children's imaginations, making it easy to communicate about them. Teachers who use ***Stuff That Works!*** usually require students to record their activities and reflections in journals.
- The activities in *Designed Environments: Places, Practices, and Plans* engage students in identifying problems in their own classrooms and schools, and in proposing, testing, and evaluating their own designs for solving these problems. Each of these endeavors requires extensive use of language in a group setting to accomplish purposes of real importance to the children.

Designed Environments: Places, Practices, and Plans engages students in recognizing soluble problems in their classroom and school environments and in designing and testing ways to organize things better. Many of these problems deal directly with the use of language, such as designing a way to answer the classroom telephone that limits the amount of interruption. Others have to do with the rearrangement of space in the classroom, rescheduling cafeteria time for better traffic flow, redesign of games, and reorganization of storage space. Each of these design projects requires considerable discussion, as well as more formal oral, written, and graphic presentations.

First, students identify the problem they want to solve, either through a brainstorming session or because it is already an obvious concern. Next they decide on the kinds of information they need to understand the problem better. At some point, they brainstorm about the criteria that a successful design would have to meet; in other words, what the design would have to do in order to solve the problem. Subsequently, they meet in small groups to come up with possible solutions. The whole class then selects a solution to implement, usually by merging some of the proposals from the groups. The students subsequently implement this design and collect data to see how well it meets the criteria.

Each of these steps engages students in using "spoken, written, [or] visual language to accomplish their own purposes." (ELA Standard #12, p. 45) The purposes are genuinely the students' own, because the design projects address problems they themselves have raised. To accomplish their goals, they have to brainstorm about the criteria the design should meet, how to collect data, and how to test the design. They have to negotiate with one another to come up with a solution everyone can accept. They have to present their ideas to one another, and sometimes to school administrators, in written, oral, and graphic forms. *Designed Environments: Places, Practices, and Plans* activities are problem-driven and social, and provide rich opportunities for developing language proficiency.

Curriculum Standards for Social Studies

The social studies encompass a variety of disciplines, all concerned with the complex and changing relationships between the individual and society. Some of these fields have traditionally been taught as separate subjects. By the early 1990's major standards-setting efforts were underway for civics, economics, geography, and history. In an effort to provide a framework for these separate disciplinary standards, the National Council for the Social Studies (NCSS) issued *Expectations of Excellence: Curriculum Standards for Social Studies* in 1994. This document is not intended to replace the individual disciplinary standards, but rather to serve as a guide for integrating them under broad interdisciplinary themes. "Teachers and curriculum designers are encouraged first to establish their program frameworks using the social studies standards as a guide, then to use individual sets of standards from history, geography, civics, economics, or other disciplines to guide the development of strands and courses within their programs." (p. 17)

According to the NCSS, a primary purpose of social studies is to prepare students for their roles as citizens in a democratic society. "NCSS has recognized the importance of educating students ... who are able to use knowledge about their community, nation, and world, along with skills of data collection and analysis, collaboration, decision-making, and problem-solving [for] shaping our future and sustaining and improving our democracy." (p. 3)

This statement covers a lot of ground, and supports both sides of a major political controversy over the role of social studies in the schools. Should students learn what their society wants them to know, or should they develop as critical thinkers who can improve the way the society works? The NCSS *Standards* say "yes" on both counts: students should not only become "committed to the ideas and values" of our society, but also learn "decision-making and problem-solving." A companion NCSS document, *National Standards for Teaching Social Studies* (1997) is even more explicit: "Social studies teachers should ... encourage student development of critical thinking." (p. 35)

What sorts of educational strategies will accomplish these goals? The Social Studies *Standards* outline five basic "Principles of Teaching and Learning." To begin with, these should be "meaningful": "Students learn connected networks of knowledge, skills, beliefs and attitudes that they will find useful both in and out of school." Learning should "integrate across the curriculum," using "authentic activities that call for real-life applications." In applying what they have learned, students should "make value-based decisions" and develop a "commitment to social responsibility." (pp. 11-12) The Teaching Standards set the context for such education, in calling for "learning environments that encourage social interaction, active engagement in learning and self-motivation." (NCSS, 1997, p. 35)

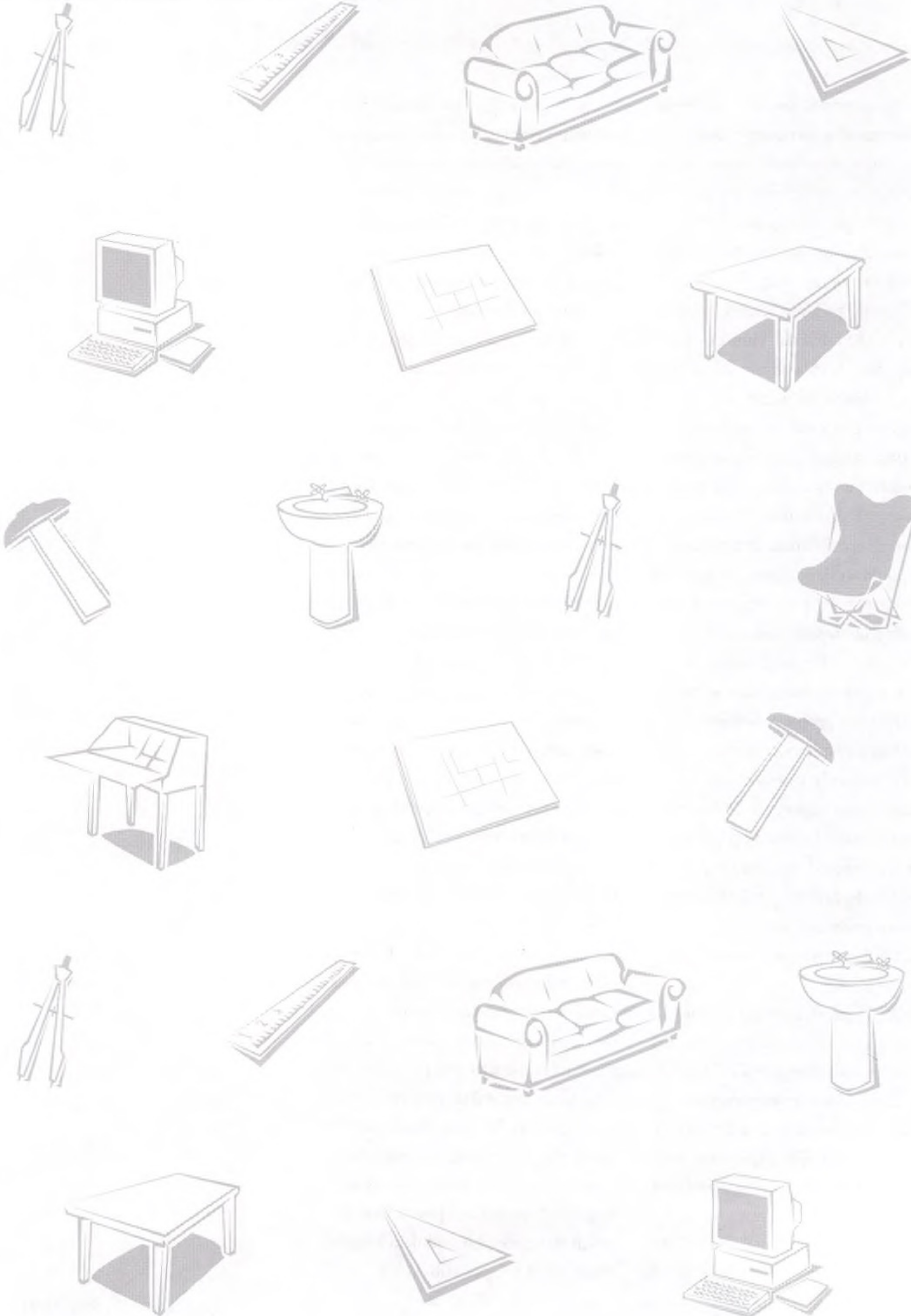
Stuff That Works! offers these sorts of opportunities, particularly through the guide *Designed Environments: Places, Practices, and Plans,* but also via activities in *Packaging and Other Structures* and *Signs, Symbols, and Codes.* In these activities, students begin with problems of real concern to them: lack of storage space in the classroom; the need to stop children from running on the stairway; frequent classroom interruptions; congestion and long waiting times in the cafeteria. To understand a particular problem better, they need additional information. Research questions might include: How much space do we have in the classroom that we could use for storage? What are the sources of the interruptions? How long do children actually have to wait in the cafeteria? How do these waiting times vary with the menu, time of day, or day of the week?

Having collected and analyzed some data, students then try to come up with solutions to one of the problems they have identified. Of course, everyone has a different idea about what would work best, and the students have to negotiate these differences. In evaluating alternative designs, they need to refer to the original design criteria. Any real design must solve more than one problem and satisfy more than one criterion. Therefore, conflicts naturally arise about which criterion is most important. Ultimately, the answer must be based on values, which are weighed in examining trade-offs. By designing solutions to their own problems, students gain meaningful experiences in democratic decision-making.

Felice Piggott's cafeteria redesign project, is an example of an extended curriculum unit that provides "for the study of the ideals, principles, and practices of citizenship in a democratic republic." (p. 30) The project not only involved students in solving a problem of importance to them, but also challenged the assumption that only adults can have a voice in how a school is run. At the beginning of the project, the students generated a brainstorming list of problems related to the cafeteria. They noted, for example, that there was food all over the floor, because children trying to throw out their garbage bumped into students who were first waiting on line to be served.

The next phase of the project was to collect data, both qualitative and quantitative, about how the space was used and organized. For this purpose, the class divided into four groups: the Traffic Team, the Food Service Team, the Garbage Team, and the Seating Team. In the course of these investigations, Felice encouraged them to distinguish between their observations and their opinions. After several weeks of collecting and organizing data, each team came up with its recommendations for improvement. For example, the Garbage Team suggested that there be an additional tray carton for soiled trays, better access to the garbage, and staff available to keep the garbage areas clean.

Each group constructed a map showing how its recommendations would look in the physical space. In examining these maps and reflecting on their proposals, students realized that some of them weren't practical, and they made further revisions. Finally, the students made a formal presentation of their ideas to the Assistant Principal, who agreed to let them implement nearly the entire plan! Through their own activity, these students learned first-hand about their power to solve problems responsibly and democratically. (See Chapter 4, pp. 108-115.)



REFERENCES

Chapter 2

Allen, Edward. ***How Buildings Work: The Natural Order of Architecture.*** New York: Oxford University Press, 1980.

This is a very accessible account of building systems, including plumbing, electrical systems, heating, cooling and ventilation, waste control, "fitting buildings to people," and much more. The illustrations are particularly good.

American Association for the Advancement of Science. ***Benchmarks for Science Literacy.*** New York: Oxford University Press, 1993.

A comprehensive statement by Project 2061 of science education goals for K-12. Chapters on "The Nature of Technology" and "The Designed World" are included.

Benenson, Gary. "The Unrealized Potential of Everyday Technology as a Context for Learning." ***Journal of Research in Science Teaching,*** 38:7, September 2001.

An analysis by the director of the City Technology project of ways in which everyday design projects support broad and deep learning across the curriculum.

Clay, Grady. ***Close-Up: How to Read an American City.*** New York: Praeger Publishers, 1973.

An entertaining look by a journalist at public urban space, including how turf is defined, how sinks form, and the evolution of commercial strips.

Dargan, Amanda and Zeitlin, Steven. ***City Play.*** New Brunswick, NJ: Rutgers University Press, 1990.

A history of how children have appropriated city space for play and created their own play activities. It is full of photographs and short quotations documenting the history of play, particularly in New York City.

Department of Education and Science (UK). ***Design and Technology for Ages 5 to 16.*** York, UK: Author, 1989.

An extensive summary of the British National Curriculum in Design and Technology, including examples of what children should learn at each level about both process and content.

Fitch, James Marston. ***American Building: Vol. 2, The Environmental Forces That Shape It.*** Boston: Houghton Mifflin Co., 1972.

Fitch is an architect who pleads with his colleagues to design buildings for more than visual impact. A building is a shield between humans and the outdoor environment, and must meet a whole variety of sensory and metabolic needs.

Gilligan, Carol. ***In a Different Voice: Psychological Theory and Women's Development.*** Cambridge, MA: Harvard University Press, 1982.

Based on research and rooted in common sense, Gilligan's analysis of female moral development causes us to look differently at all human development.

Givoni, B. ***Man, Climate and Architecture*** (Second Edition). New York: Van Nostrand Reinhold, 1981.

A fairly technical book, which focuses both on the human physiological response to environmental factors and the role of buildings in meeting human needs.

Graves, Ginny. ***Walk Around the Block.*** Prairie Village, Kansas: Center for Understanding the Built Environment, 1992.

A compendium of one-page curriculum ideas for looking at buildings, city blocks and neighborhoods, mapping, exploring environmental issues, and taking action. The intended audience is upper elementary and junior high school levels.

Hall, Edward T. ***The Dance of Life: The Other Dimension of Time.*** New York: Anchor Books, 1989.

This book reveals many of the subtle assumptions built into different cultures about the handling of time. Much of it compares the handling of time in European and non-European societies.

Hall, Edward T. ***The Hidden Dimension.*** New York: Anchor Books, 1990.

This is Hall's groundbreaking account of spatial behavior, originally published in 1966, which established the field of proxemics. Hall discusses territorial behavior in animals and humans, and considers the ways in which different cultures handle space.

Halprin, Lawrence. ***The RSVP Cycles: Creative Processes in the Human Environment.*** New York: George Braziller, 1970.

The author, an architect, uses the musical score as a model for producing "scores" or schedules to describe and/or plan a wide variety of activities and events. This book is very broad in scope and offers a wealth of ideas for expressing schedules.

Hart, Roger. ***The Changing City of Childhood: Implications for Play and Learning.*** New York: The City College Workshop Center, 1986.

Hart argues that modern cities and changes in society have robbed most children of opportunities to create and learn from their environments.

Hart, Roger. "Children's Participation in Planning and Design" in C. Weinstein and T. Davids (eds.), ***Spaces for Children.*** New York: Plenum, 1987.

Hart presents theory, research, and practice that relate to children constructing environments for their own use.

International Technology Education Association. ***Technology for All Americans: A Rationale and Structure for the Study of Technology*** (draft). Reston, VA: Author, 1995.

Preliminary effort to define what all students should learn about technology.

Kunstler, James Howard. ***The Geography of Nowhere: The Rise and Decline of America's Man-Made Landscape.*** New York: Simon & Schuster, 1993.

This book is partly a history of the takeover of our landscape by the automobile, and partly an examination of the social, economic, and environmental effects. The final chapter suggests ways to design more livable cities.

National Research Council. ***National Science Education Standards.*** Washington: National Academy Press, 1996.

The most authoritative statement to date of what the goals of K-12 science education should be. Each set of content standards, for grades K-4, 5- 8, and 9-12, respectively, contains a section on "Science and Technology."

New York State Education Department. ***Learning Standards for Mathematics, Science and Technology.*** Albany, NY: Author, 1996.

A curriculum standard which develops a paradigm for integrating math, science, and technology from K-12.

O'Connor, Maura and McGlauflin, Kathy. ***Living Lightly in the City: An Urban Environmental Education Curriculum Guide.*** Milwaukee: Schlitz Audubon Center, 1990.

This loose-leaf book includes teacher information and activity sheets for introducing global and local environmental issues in the upper elementary grades. The teacher information is in the form of lesson plans.

Olgyay, Victor. ***Design with Climate: A Bioclimatic Approach to Architectural Regionalism.*** New York: Van Nostrand Reinhold, 1992.

A classic work, originally written in 1963, which shows architects how to take account of sun and wind patterns in creating energy efficient designs. This book has a wealth of information about the effects of climate on buildings and people.

Sommer, Robert. ***Design Awareness.*** San Francisco: Rinehart Press, 1972.

Sommer develops his ideas on the roles consumers should play in the design and management of their environments. He then provides ways to assess existing designs and use the resulting information to develop new and better designs.

Sommer, Robert. ***Personal Space: The Behavioral Basis of Design.*** Englewood Cliffs, NJ: Prentice-Hall, 1969.

A social psychologist's survey of empirical research on how people use space. Included are studies of where students sit in libraries, use of territorial markers to define personal space, and how people react to invasions of their space.

Vergara, Camilo José. *The New American Ghetto.* New Brunswick, NJ: Rutgers University Press, 1995.

A beautiful but very disturbing book of photographs and text documenting the decline and abandonment of inner cities over the last twenty to fifty years. Through individual photos and sequences, Vergara shows how once proud, vibrant cities have been reduced to rubble, overgrown, or converted to marginal uses.

Whyte, William H. City: *Rediscovering the Center.* New York: Anchor Books, 1990.

Whyte is a well-known sociologist who has done extensive studies of how people use public urban spaces, including streets, sidewalks, and plazas. In part, this book is an account of his research; in part it is a plea for restoring cities to their historic role as public gathering places.

Wilson, Forrest. *A Graphic Survey of Perception and Behavior for the Design Professions.* New York: Van Nostrand Reinhold Co., 1984.

A compendium of information about human behavior that is relevant to architecture and interior design.

Chapter 6

American Association for the Advancement of Science. (1989) *Science for All Americans: A Project 2061 Report on Literacy Goals in Science, Mathematics and Technology.* Washington, DC: Author.

American Association for the Advancement of Science. (1993) *Benchmarks for Science Literacy.* New York: Oxford University Press.

American Association for the Advancement of Science. (1997) *Resources for Science Literacy.* New York: Oxford University Press.

American Association for the Advancement of Science. (1998) *Blueprints for Reform.* New York: Oxford University Press.

American Association for the Advancement of Science. (2001) *Designs for Science Literacy.* New York: Oxford University Press.

International Technology Education Association. (1996) *Technology for All Americans: A Rationale and Structure for the Study of Technology.* Reston, VA: Author.

International Technology Education Association. (2000) ***Standards for Technological Literacy: Content for the Study of Technology.*** Reston, VA: Author.

National Center on Education and the Economy. (1997) ***New Standards Performance Standards; Vol 1: Elementary School.*** Washington, DC: Author

National Council for the Social Studies. (1994) ***Expectations of Excellence: Curriculum Standards for Social Studies.*** Washington, DC: Author.

National Council for the Social Studies. (1997) ***National Standards for Social Studies Teachers.*** http://www.social studies.org/standards/teachers/standards.html

National Council of Teachers of English and International Reading Association. (1996) ***Standards for the English Language Arts.*** Urbana, IL: Author.

National Council of Teachers of Mathematics. (1989) ***Curriculum and Evaluation Standards for School Mathematics.*** Reston, VA: Author.

National Council of Teachers of Mathematics. (2000) ***Principles and Standards for School Mathematics.*** Reston, VA: Author.

National Research Council. (1996) ***National Science Education Standards.*** Washington, DC: National Academy Press.