Critical Issue: Science Education in the Era of No Child Left Behind—History, Benchmarks, and Standards

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ISSUE:

It has been well over a decade since the publication of two important documents relating to science standards: *Benchmarks for Science Literacy* (American Association for the Advancement of Science [AAAS], 1993) and *National Science Education Standards* (National Research Council, 1996). In the *National Science Education Standards*, the National Research Council spelled out what all students should know and be able to do in science at Grades K–4, 5–8, and 9–12. In addition, the emphasis on content standards has been further strengthened with the release of the No Child Left Behind (NCLB) Act, which made content standards a required part of federal and state accountability systems. The law also mandates that beginning in the 2007–08 school year, schools must administer annual tests in science achievement at least once in Grades 3–5, 6–9, and 10–12.

With such powerful mandates in effect, the expectations are that all students will achieve academic excellence in all subject areas—including science. But although state science standards have been drafted, teaching practices in science still need to be aligned to the standards. As one *Associated Press* reporter noted, science has fallen into a "quiet crisis," while mathematics and reading have taken the limelight (Feller, 2004).

In spite of a number of efforts to keep science from becoming a second-class discipline, achievement scores in science have shown only unsteady gains. In their *Science* editorial discussing the Trends in International Mathematics and Science Study (TIMSS) test for 2003, Bybee and Kennedy (2005) summarize the international-level findings: "At Grade 4, between 1995 and 2003, U.S. student scores held constant, although their international ranking declined slightly. But the average scores of U.S. eighth-graders made statistically significant improvements between 1995 and 2003 in both mathematics and science" (p. 481).

In light of NCLB mandates and ongoing concerns for science education, this Critical Issue provides an overview of how science standards have evolved to the current state, how they are making a difference in science instruction and achievement, how the professional field should be responding to the need for all students to reach academic excellence, and what action steps are required to boost progress in science education. Besides providing a complete historical and evolutionary documentation of standards, the Critical Issue also offers valuable information to individuals who are very experienced and knowledgeable about science standards as well as novices.

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OVERVIEW:

Standards

Standards are guidelines that serve multiple purposes in education. Because they give educators clear parameters for what students should know and be able to do in Grades K–12 in most subject areas, standards also become helpful criteria to evaluate the quality of academic programs and instruction. Unfortunately, the importance of standards has been dismissed quite often by the field. John Whitsett, physics teacher at Fond du Lac High School in Wisconsin, explains:

> "Many of those currently in the field have no knowledge of the reforms that were attempted in the 1960s. Many of these reform efforts were well founded in research and would actually have accomplished much of what is now being attempted through the standards. The issue at that time was that not enough schools and districts adopted these programs with enough insight to allow for them to be effective. Many of the attempts to implement were 'business as usual' methods and procedures using the 'alphabet soup' curricular programs. Unfortunately, this made them ineffective." (J. Whitsett, personal communication, July 10, 2005)

Any standards development is a long-term task. An enormous effort of expertise, time, commitment, and sensitivity to the needs of the nation's students forms the groundwork of standards writing. To help readers understand how science standards can help build science curricula that are consistent and congruent, it is important to take a look at the historical perspective on standards development.

History of Standards

Since the 1960s and '70s, science has come a long way from the "alphabet soup" curricula—so named because they often were referred to by their acronyms. A few examples of such curricula and projects include the Earth Science Curriculum Project (ESCP), Chemical Education Material Study (CHEM Study), Science Curriculum Improvement Study (SCIS), Elementary Science Study (ESS), Biological Sciences Curriculum Study (BSCS), and others. The impact of these efforts on instruction was limited; however, as a result of these initiatives, textbook publishers began to offer hands-on curricula.

The National Commission on Excellence in Education, was formed on August 26, 1981, and was directed to present a report on the quality of education in America. The committee's 1983 report, *A Nation at Risk: The Imperative for Educational Reform*, called for reform of the U.S. educational system. Many educators have viewed this publication as the starting point of a movement toward standards and accountability as well as a more equitable educational system. This report noted a steady decline in science achievement among 17-year-olds, with declining achievement most prevalent in physics. Among its recommendations, the report called for a three-year science requirement for high school graduation and a focus on providing students with an understanding of concepts, inquiry, real-world learning, and personal implications. The following recommendations appeared in the report:

> "The teaching of science in high school should provide graduates with an introduction to: (a) the concepts, laws, and processes of the physical and biological sciences; (b) the methods of scientific inquiry and reasoning; (c) the application of scientific knowledge to everyday life; and (d) the social and environmental implications of scientific and technological development."

Besides making recommendations for the content of the curriculum, the report also called for more rigorous standards and higher expectations for students, more time devoted to schoolwork in general, and high-quality teacher preparation, as well as increased fiscal support and the necessary leadership to make these reforms possible. A formal plea was made to both parents and students. Foremost, the National Commission on Excellence in Education worked on the belief that everyone can learn and set forth an impetus that all students born in 1983 would be expected to graduate in the year 2000.

In 1985, AAAS began Project 2061, a long-range effort to help American students achieve scientific literacy. (The name Project 2061 was derived from the fact that during the year the project was launched—1985—Halley's comet passed by the Earth with an estimated date of its return of 2061. Hence, children entering school at the comet's appearance were expected to become scientifically and technologically literate during their lifetime, which would span the years before the return of the comet in 2061.) As part of Project 2061, AAAS published *Science for All Americans* (Rutherford & Ahlgren, 1990), which provided a set of recommendations for mathematics, science, and technology education, followed by the 1993 publication of *Benchmarks for Science Literacy* .

In response to *A Nation at Risk*, President George H.W. Bush and the governors called a National Education Summit in 1989. The summit established six broad goals for education to be attained by the year 2000. These six education goals were announced in the State of the Union address in 1990. Soon thereafter, the National Education Goals Panel was formed. The final outcome of the summit was a 1991 report called *The National Education Goals Report: Building a Nation of Learners, 1991* (National Education Goals Panel, 1991). Goals 3 and 4 reflected expectations for students in mathematics and science specifically as follows:

> "**Goal 3:** By the year 2000, American students will leave grades 3, 8, and 12 having demonstrated competency in challenging subject matter including English, mathematics, science, history, and geography, and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our modern economy.
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> "**Goal 4:** By the year 2000, U.S. students will be first in the world in science and mathematics achievement." (National Education Goals Panel, 1991)

During the next 10 years, the National Education Goals Panel reported on progress that the nation and states made towards meeting the goals, culminating in the report *Building a Nation of Learners, 1999* . This report suggested that the panel had had an impact in bringing more focus to results, sustaining education reform, helping to launch academic standards, supplying comparable data so that states could monitor their progress toward National Assessment of Educational Progress benchmarks, and advocating for educational performance improvement (National Education Goals Panel, 1999, p. 2). (A complete history of the decade of the panel's work can be found at National Education Goals Panel: History, 1989 to Present.)

However, even with some progress, there was concern about the achievement of U.S. students in science and mathematics competitively at the international levels, especially in the upper grades. Prior to the National Education Goals Panel, there was no established way to benchmark states against the highest performing nations in the world in mathematics and science achievement. Thus, the panel helped promote and build interest in international comparisons.

To further address the education goals for the year 2000, the Secretary's Commission on Achieving Necessary Skills (SCANS) was formed in 1990 to determine the skills necessary for success in the workplace and to take a closer look at how well schools prepare students with these skills. The essential competencies— resources, interpersonal competencies, information, systems, and technology—and foundational skills—basic skills, thinking skills, and personal qualities—of an effective worker are detailed in *What Work Requires of Schools* (SCANS, 1991) and in a summary of the publication .

In 1991, Congress set up the National Council on Education Standards and Testing (NCEST) to help reach consensus on national standards and testing. Its 1992 report, titled *Raising Standards for American Education*, called for the establishment of an oversight board, the National Education Standards and Assessment Council, charged with a task of checking content, performance, and assessment standards. Even earlier, the National Council of Teachers of Mathematics (NCTM) writing teams had begun to draft standards in both curriculum and evaluation as early as 1987. It had become the leader in establishing mathematics standards in 1989 with its publication of *Curriculum and Evaluation Standards for School Mathematics* . Following the lead of NCTM, organizations in many other subject areas began to investigate the establishment of content standards during 1992.

Publishing of the *National Science Education Standards*. The *National Science Education Standards* , published in 1996, provided a framework for science excellence.

Despite the push for science education from the 1990 publication of *Science for All Americans* and the 1993 publication of *Benchmarks for Science Literacy*, the 1994 reauthorization of the Elementary and Secondary Education Act did not emphasize science. The law required states to develop challenging content standards in mathematics and language arts only, with no mention about the discipline of science. For each content standard, a performance standard of "partially proficient," "proficient," or "advanced" was to be used. All students were expected to meet the same standards and levels of proficiency. States were charged with aligning content and performance standards.

In the fall of 1999, governors, educators, and business leaders met at the third National Education Summit. They identified three main challenges faced by schools in the United States: teacher quality, high standards, and accountability. Out of this meeting came an agreed-upon commitment to address these issues in each of the states.

In 2000, the National Commission on Mathematics and Science Teaching for the 21st Century published *Before It's Too Late* in response to the needs of mathematics and science education. This publication, often referred to as the Glenn Report, called the preparation that U.S. students receive in mathematics and science "unacceptable" (National Commission on Mathematics and Science Teaching for the 21st Century, 2000, p. 7). The report made two important points: (1) "American students must improve their performance in mathematics and science if they are to succeed in today's world and if the United States is to stay competitive in an integrated global economy" and (2) "the most direct route to improving mathematics and science achievement for all students is better mathematics and science teaching" (National Commission on Mathematics and Science Teaching for the 21st Century, 2000, p. 7).

The No Child Left Behind (NCLB) Act, a reauthorization of the Elementary and Secondary Education Act, was signed into law in 2002. Regarding science education, the NCLB Act requires challenging content standards for science by the 2005–06 school year. Beginning in the 2007–08 school year, all states must administer science assessments at least once in Grades 3–5, 6–9, and 10–12. In addition, the law mandates that *all* students must achieve at proficiency level, to be determined by each state, by the

2014–15 school year.

The NCLB Act was passed with the intent of achieving the goals established by the third National Education Summit in 1999: to improve teacher quality, set high standards, and maintain accountability. Alignment with state standards is one of the criteria that define quality data in a new era of accountability under the NCLB Act. "States will be held accountable for deliverables (e.g., adequate yearly progress determinations, annual report cards, diagnostic assessments aligned with academic standards and linked to the state's assessments)" said Glynn Ligon (2004), president of ESP Solutions Group at the "Empowering Accountability and Assessment Using Technology" Summit in March 2004. *Understanding the No Child Left Behind Act of 2001: Mathematics and Science* provides key NCLB requirements for mathematics and science.

In response to NCLB mandates, states have now written their own science content standards using the *National Science Education Standards* as a guide. States have chosen a variety of approaches to their coverage of standards. For example:

- Wisconsin's Model Academic Standards for science mirror the *National Science Education Standards* in that they cover grade-level spans.
- California has content standards for science that are grade-level specific.
- The state of Ohio, at its Model Curriculum Web page, provides grade-level lesson plans correlated to specific standards.

State standards have now been developed for almost all of the educational content areas across the states. Individual state standards can be found at StateStandards.com. In addition, the Council of Chief State School Officers (CCSSO) has gathered state content standards by state with Web links to the standards. In response to standards development and implementation efforts, many publishers state their textbooks are now correlated to the standards, sometimes even very elaborately to specific state standards.

U.S. Science Education From an International Perspective

The Trends in International Mathematic and Science Study (TIMSS)—formerly known as the Third International Mathematics and Science Study—provides international comparative information on U.S. mathematics achievement in the primary and middle grades. TIMSS results often have been interpreted as an outcome of a school curriculum that is "a mile wide and an inch deep" (Schmidt, 2003). Some educators, however, have countered this interpretation. According to Bruce Alberts (1997), former president of the National Academy of Sciences, in both mathematics and science, "our fourth-grade curricula, textbooks, and teaching are more focused than at eighth grade."

In 2003, 49 countries participated in the TIMSS assessment. (Full reports are available at the TIMSS 2003 Web site .) According to a TIMSS 2003 summary report (Gonzales et al., 2004), fourth-grade students in the United States scored an average of 536 in science, exceeding the international average of 489 for the 25 participating countries in science. Students in three countries—Chinese Taipei, Japan, and Singapore—outperformed U.S. students in fourth grade, while U.S. fourth graders outscored students in 16 countries (Gonzales et al., 2004).

Regarding U.S. eighth-grade students, the average science score in TIMSS 2003 was 527, exceeding the international average of 473 for the 45 participating countries. They were outperformed by their peers in seven countries, including Chinese Taipei, Hong Kong (Special Administrative Region of the People's Republic of China), Japan, Korea, Singapore, Estonia, and Hungary, and outscored students in 32 of the 44 other countries (Gonzales et al., 2004).

Even though U.S. students are getting higher academic standings in the world, reports continue to be varied on the U.S. students' comparison to the rest of the world. According to an article by the Associated Press (2004), the news of TIMSS 2003 results are not as promising for U.S. fourth graders as they are for eighth graders: "U.S. eighth-grade students are improving in science and mathematics compared with international peers, but the nation's fourth-graders have stagnant scores and are slipping behind in both subjects." *USA Today* (Toppo, 2004) also reports that U.S. fourth graders are having difficulty in keeping up with their older counterparts. Comparing results of countries included in both the 1999 and the 2003 TIMSS (additional countries were included in the 2003 TIMSS), eighth graders rose from 14th to seventh in science, while fourth graders dropped from rank two to five (Toppo, 2004). In addition, the National Science Foundation (2004) commented on modest yet significant gains at fourth and eighth grades among African-American and Latino students.

> "Teaching is really hard to change, and the reason that it is really hard to change is because it's a cultural activity. When we try to change cultural activities, usually what happens is culture wins. There are many examples of this in education. One [example] that I find quite interesting from our most recent TIMSS video studies looked at the ways rich mathematical problems are used in eighth-grade classrooms in seven different countries—some not very high achieving like ours, and six of them achieving higher than the United States. And what we found is that even though we have many of these great new curriculum materials that are getting put out by R&D from the National Science Foundation and so on, teachers transform those materials. So problems designed for teaching rich mathematical concepts get into the classrooms, particularly in the United States , and teachers transform them into routine procedural exercises. So the point I am trying to make is you can make teachers smarter and more knowledgeable, but it is very, very hard to penetrate the classroom wall in professional development. Yet that is what we must do. If we cannot improve the quality of teaching and learning in classrooms, then everything else we do is not going to get anywhere." (U.S. Department of Education, 2004b)

Science Curriculum and Instruction

Krueger and Sutton (2001, p. 47) summarize several strategies for addressing standards in science instruction. Those recommendations include the following:

- *Less emphasis on*: (1) knowing scientific facts and information; (2) studying subject matter disciplines (physical, life, earth sciences) for their own sake; (3) separating science knowledge and science process; (4) covering many science topics; and (5) implementing inquiry as a set of processes.

- *More emphasis on*: (1) understanding scientific concepts and developing abilities of inquiry; (2) learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science; (3) integrating all aspects of science content; (4) studying a few fundamental science concepts; and (5) implementing inquiry as instructional strategies, abilities, and ideas to be learned.

The following publications, initiatives, and programs in science education can assist teachers in classroom instruction using the standards. They should give a quality head-start for districts embarking upon the journey of selecting materials and improving science programs.

Atlas of Science Literacy. In 2001, Project 2061 (the long-term initiative of the American Association for the Advancement of Science working to reform K–12 science, mathematics, and technology education nationwide) and the National Science Teachers Association copublished the *Atlas of Science Literacy* , a collection of conceptual strand maps that show how students' understanding of the ideas and skills that lead to literacy in science, mathematics, and technology might grow over time. Each map depicts how K–12 learning goals for a particular topic relate to each other and progress from one grade level to the next.

Science NetLinks. A useful curriculum development tool is Science NetLinks, developed by the American Association for the Advancement of Science. The tools contain reviewed Internet resources, as well as K–12 lessons sorted by grade level, lesson title, or benchmark.

Publications for Educators. Several publications also have been released to assist educators in designing and selecting educational materials as well as teaching inquiry:

- *Designing Mathematics or Science Curriculum Programs: A Guide for Using Mathematics and Science Education Standards*

  This 1999 document helps state- and district-level mathematics and science curricula developers design multiyear curriculum programs that provide students with the opportunity to learn in a continuous, interconnected, and cumulative way.

- *Selecting Instructional Materials: A Guide for K–12 Science*

This 1999 report by the Committee on Developing the Capacity for Selecting Effective Instructional Materials is addressed to school districts, school district administrators, individual schools, school administrators, teachers, scientists, school boards, parents, and the community at large. It provides a tested procedure and selection of K–12 science instructional materials that is consistent with state and/or national standards and thereby supports the learning of science by all students.

- *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning* (2000) is a practical guide for teachers, professional developers, administrators, and others who wish to respond to the call from the *National Science Education Standards* for an increased emphasis on inquiry.

- *Networking for Leadership, Inquiry, and Systemic Thinking (NLIST): Science as Inquiry*. Proposed jointly by the Council of State Science Supervisors and the Education Division of the National Aeronautics and Space Administration, NLIST has initiated key networking processes and is producing useful Internet products for more effective science education program implementation.

National Science Foundation Curriculum Materials. The National Science Foundation (NSF) has funded the development of high-quality, highly tested curriculum materials to assist educators in their decision making. Through grants and contracts, NSF initiates and supports education programs at all levels, from prekindergarden through graduate school and beyond. Part of its mission is providing support for science and engineering education. Funded research is integrated with education. Its activities include increasing participation of women, minorities, and other underrepresented populations in science and technology.

Exemplary and Promising Science Programs. In late 1990s, the U.S. Department of Education formed the Expert Panel on Mathematics and Science Education to oversee a quality process for identifying and designating exemplary and promising programs in mathematics and science (Mathematics and Science Expert Panel, 2001). The panel's goal was to help practitioners make informed decisions in their efforts to improve the quality of student learning in mathematics and science. It was composed of 14 experts from across the country, including academics, association representatives, regional educational laboratory representatives, and practitioners. The panel identified exemplary and promising science programs.

State-Based Information. Various states provide their teachers with information on standards-based instruction and planning. The Ohio Department of Education is a good state-level example of offering information on standards to teachers; it first focuses on explaining *standards-based education*: "Standards-based instruction is a process for delivering, monitoring and improving education in which all educational planning and implementation begins with the state Academic Content Standards" (Ohio Department of Education, n.d.). It then lists ideas on planning standards-based instruction and provides sample lesson plans that are aligned to the Ohio state standards in science.

The Benefits of Standards-Based Instruction. Because the *National Science Education Standards* does not provide a science curriculum and its use is voluntary, science educators need instructional strategies that promote science excellence. Standards-based instruction is a means to align the science standards with classroom instruction.

Assessment in Science Education

Assessment is a central focus of the standards movement, yet many classroom teachers believe their "primary goal is to develop science literacy, not to test it" (Champagne, n.d.). Often teachers believe assessment takes too much time from their instruction. They feel pressured to learn how to incorporate as much of the standards as they can into their instructional methods. Because of the pressure to teach to the standards, teachers often may feel that they are teaching to the test.

To alleviate the tension teachers often feel about assessment, it is important for them to know the specific goals and purposes of assessment. There are several purposes of assessment in science education: monitoring student progress, planning instructional activities, and formulating education policy (Champagne, n.d.). National science standards help specify these purposes. Of the 28 standards in the *National Science Education Standards,* five are assessment oriented:

- **Assessment Standard A:** "Assessments must be consistent with the decisions they are designed to inform." (p. 78)
- **Assessment Standard B:** "Achievement and opportunity to learn science must be assessed." (p. 79)
- **Assessment Standard C:** "The technical quality of the data collected is well matched to the decisions and actions taken on the basis of their interpretation." (p. 83)
- **Assessment Standard D:** "Assessment practices must be fair." (p. 85)
- **Assessment Standard E :** "The i nferences made from assessments about student achievement and opportunity to learn must be sound." (p. 86)

The data collected from assessments is meant to inform and improve instruction. Likewise, certain instructional decisions help teachers gather data about students' understanding and their thinking processes.

Abbey Leppien, a fourth-fifth grade teacher at Bertha Vos Elementary School in Michigan , speaks about the kinds of instructional decisions that help her assess student understanding. [Video: :50]

Regardless of the type of assessment, it is important to ensure alignment across science content standards, opportunities to learn in the classroom, and the tests (both published tests and classroom tests) used to measure progress toward proficiency in the discipline. Providing students opportunities to learn is critical because the content calls for differentiating instruction to meet individual learner needs. Formative feedback (e.g., through concept mapping and science portfolios) forms a significant basis for success—both for students and for teachers.

Eric Dreier, science coordinator for the Traverse City Area Public Schools, says that standards-based assessment can be referred to as a bull's eye—a metaphor for accountability. [Video: :30]

Well-designed formative assessments positively affect student role, motivation, and self-perception, which allow students to view assessment as supportive rather than punitive (Barchfeld-Venet, 2005; Sadler, 1989). Studies indicate that evaluation and reflection involving analysis and feedback are important aspects of effective teaching (McAninch, 1993).

The National Center for Education Statistics (NCES) collects data on how U.S. students perform in various subject areas, including science. NCES receives student achievement data from the National Assessment of Educational Progress (NAEP), TIMSS, and the Program for International Student Assessment (PISA). A comparison of the three assessments appears in a publication titled *Comparing NAEP, TIMSS and PISA Results in Mathematics and Science* (NCES, n.d.). With tests being given on a regular cycle, this information changes on a yearly basis. The most current data appears on the NCES Web site. In addition, the National Research Council (NRC), a division of the National Academies, published *Systems for State Science Assessments*, which provides states with guidance on science assessments, tools and ideas, and a detailed look at K–12 science assessment.

All three assessments are sample based (i.e., administered to a subgroup of students, with the results generalized). NAEP and TIMSS assessments are grade based, while PISA uses an age base of 15. NAEP targets fourth, eighth, and 12th grades, while TIMSS tracks fourth and eighth grades, particularly in 2003. Results of TIMSS in 2003 showed U.S fourth- and eighth-grade students performing above the international average, while PISA in 2003 showed 15-year-olds below the international average. Reasons for variance in performance on the tests can be attributed to different content areas and item design, as well as different countries in the studies.

In the era of the NCLB Act, the initial emphasis has fallen onto reading and mathematics, which has had "the unfortunate consequence of further marginalizing science in some districts, particularly at the elementary level" (Tugel, 2004, p. 1). Evidence from TIMSS and NAEP point to the neglected stage of K–12 science education. With the NCLB requirement to administer science assessments at the beginning of the 2007–08 school year, many schools are looking for ways to bring science back into the spotlight and the core curriculum (Tugel, 2004).

One way the issue of helping students achieve science standards has been addressed through connecting science and language arts to foster positive interdependence between science and literacy. Programs that do make this connection typically use inquiry-based activities and science notebooks, as well as professional development for teachers (Tugel, 2004). Science notebooks are used by students similarly to the way they are used by scientists for writing. Such notebooks serve as a formative assessment tool, giving teachers better understanding of their students' thinking (Tugel, 2004). However, for such programs to work, the key ingredient is providing professional development for teachers as well as time for professional development.

Professional Development for Science Educators

The issue of teacher preparation is central to the NCLB Act. The law mandates a set of requirements that have a great impact on both teacher preparation and professional development. It requires schools to have a highly qualified teacher in every classroom so that by the end of the 2005–06 school year, all students will be taught by highly qualified teachers. Peter Gibbon (2005), a senior researcher at Boston University's School of Education, wrote about the importance of teachers to improvement in education through history: "As in *A Nation at Risk*, a key component of No Child Left Behind is 'a qualified teacher in every classroom.' " The "highly qualified teacher" provision of the NCLB Act states that all teachers need to demonstrate competency in the subject area they teach. In spite of some latitude in the interpretation of the law, the NCLB Act emphasizes the development of content knowledge and skills aligned with state's content area standards.

The *National Science Education Standards* presents a vision of science education. It calls the nation to prepare a teaching force qualified to teach science content to all students. The standards for professional development focus on four areas:

- Learning of science content through inquiry.
- Integration of content and pedagogical knowledge.
- Development of understanding and ability for lifelong learning.
- Coherence of professional development programs.

Professional development standards for science teachers call for continued growth with a special emphasis on deepening understanding of content knowledge of science and pedagogical knowledge to teach science.

Taking these standards for professional development a step further, a critical issue for teachers is to experience professional development that supports content standards and frameworks to promote learning for all students. In a day and age where students' outcomes are becoming the foundation if not the sole target of accountability systems, professional development opportunities must focus on student learning and provide teachers with experiences that enhance the processes, products, and conditions where learning is taking place.

A growing demand for teaching strategies that claim an impact on students' learning makes it especially critical to define the key qualities of effective professional development initiatives. In an Eisenhower National Clearinghouse publication titled *Ideas That Work: Science Professional Development*, Susan

Loucks-Horsley (1998) describes five qualities of effective professional development:

- "Professional development experiences must have students and their learning at the core—and that means all students."
- "Excellent science teachers have a very special and unique kind of knowledge that must be developed through their professional learning experiences."
- "Principles that guide the improvement of student learning should also guide professional learning for teachers and other educators."
- "The content of professional learning must come from both inside and outside the learner and from both research and practice."
- "Professional development must both align with and support system-based changes that promote student learning."

In addition to the effective qualities of professional learning experiences, Loucks-Horsley, Hewson, Love, and Stiles (1998) identify an array of strategies for effective professional development aiming at the following five goals:

- Developing awareness of effective teaching practice.
- Building knowledge of science content.
- Translating new knowledge to improve teaching.
- Practicing new teaching strategies.
- Engaging in a process of reflection around strategies to improve student learning.

The standards, qualities, and purposes of effective professional development are helpful guidelines for decision making by school administrators and teachers. However, decisions regarding good choices for professional development opportunities must be addressed on an individual basis. The prevailing question regarding what counts as good professional development remains tightly connected to the specific context and needs of those whose professional growth must be supported.

Science teacher professional development has been addressed through multiple strategies and programs. The National Science Teachers Association (NSTA) offers a venue for professional development needs through its NSTA Institute. The Web site lists current online courses, seminars and symposia that are offered for science educators, as well as courses offered by NSTA and their partners.

The Mathematics and Science Partnerships (MSP) program is an effort of the U.S. Department of Education and the National Science Foundation to support the implementation of the NCLB Act. At the core of this program is the development of a highly qualified teaching workforce in mathematics and science in high-need school districts with the support of higher education faculty in science, technology, engineering, and mathematics. The goal of the MSP program is to increase the academic achievement of all students in mathematics and science by enhancing teacher quality, quantity, and diversity in K–12 teaching workforce. Individual states are responsible for the distribution of MSP funds through competitive grant competition.

Lesson Study as a Professional Development Strategy. Several professional development strategies for educators are particularly promising, especially Lesson Study. This collaborative strategy aims at the five goals of effective professional development listed earlier. The claim that Lesson Study is indeed effective practice is supported both by research and testimonial accounts from practicing teachers and administrators who have experienced the power of collaborative inquiry.

The Value of Parent Involvement in Science Education

Successful learning is not solely dependent on schools and teachers. Parents are an integral and critical part of that process. Educators have continually emphasized the role of parents in educational issues. In 1983, this topic was addressed in *A Nation at Risk*. Currently, the NCLB Act has specifically addressed the parents' role in their child's education.

Parents often will say, "I don't know science," "I was terrible at science," or "I am not a scientist." Yet to truly help a child with science, one does not need to be a scientist. Taking the time and pleasure to nurture a child's curiosity and helping a child develop good questioning skills from that curiosity are what is important. The following resources may be helpful for parents.

- The publication titled *Helping Your Child Learn Science* (U.S. Department of Education, 2005) offers activities for parents with their children in Preschool through Grade 5 to support children's learning of science at home, at school, and in the community. It is aligned with the *National Science Education Standards* and reflects the importance of fostering inquiry and content knowledge.

- *No Child Left Behind: A Parents Guide* (U.S. Department of Education, 2003) provides parents with information about the NCLB Act requirements in a summary format. It is designed to answer parents' frequently asked questions and addresses the main provisions in the law.

- The Ohio Department of Education has developed a series of *Standards Guides for Families* appropriate for parents with students in Grades K–8. Each guide offers parents a condensed version of hundreds of pages of standards so that they can fully understand what children need to know and be able to do at each grade.

Some individual school districts also have published parent guides to standards. For example, guides developed by the Cleveland (Ohio) Municipal School District inform parents what their child will be learning during the school year in major academic subjects. The standards are listed as indicators by grade and provide specific statements of the knowledge and skills the student must demonstrate.

Milwaukee (Wisconsin) Public Schools also developed a series titled *Learning Targets* for parents of students in kindergarten through high school. The *Learning Targets* were derived directly from Wisconsin state standards for each grade level. They describe what student should know and be able to do in specific content areas.

GOALS:

In the era of the NCLB Act, science education should encompass the following goals:

- The science curriculum teaches the scientific concepts and processes outlined in the *National Science Education Standards*.
- The science curriculum incorporates the content and processes of science.
- The science curriculum provides meaningful, engaged learning for all students.
- The science curriculum engages students in challenging, authentic, interdisciplinary tasks.
- The science curriculum links scientific concepts and processes with prior learning in science and other disciplines.
- The science curriculum engages all learners in meaningful scientific tasks involving high-order thinking skills.
- The science curriculum provides a hands-on approach to learning.
- The science curriculum eliminates discipline boundaries when natural, logical, and appropriate.
- The science curriculum provides opportunities for students to observe, explore, and test hypotheses.
- The science curriculum encourages the students' imagination, logic, and open-mindedness.

ACTION OPTIONS:

Administrators, curriculum design teams (consisting of administrators and teachers, with the help of scientists and leaders from the community), teachers, students, and parents can take the following actions to support the alignment and articulation of standards in science education.

Administrators:

- Understand and support the *National Science Education Standards* and be aware of influential reports that affect science education.
- Be active and directional in helping schools implement high standards for all students.
- Become well versed in the key issues of the NCLB Act, which is designed to increase the educational achievement of all American students, improve teaching, increase accountability, ensure teachers are highly qualified, and expand parental participation.

- Support and practice (if applicable) state-level education standards.
- Ensure that teachers have the time and support they need to implement the science curriculum in the classroom. Specifically, provide adequate time for science learning and teacher preparation.

Curriculum Design Teams:

- Periodically review the school's science curriculum.
- Ensure the time and support needed for designing or reshaping the curriculum in science.
- Align the existing science curriculum with the national or state standards.
- Focus on a less-is-more curriculum, teaching fewer subjects with greater depth.

Teachers:

- Use national science standards for all students, but do not regard them as a prescribed science curriculum.
- Adapt science standards in unique ways to raise the performance of all students.
- Inform parents and community members of new approaches to teaching.
- Discuss new initiatives with parents and community members.
- Link science learning with prior learning in science and other disciplines.
- Build student inquiry in science.
- Become empowered to make decisions about implementing the new curriculum in the classroom. Such empowerment promotes decision making, collaboration, professional development, and an improved curriculum.
- Become skilled, knowledgeable, and involved in designing and selecting instructional science materials.
- Embed research-based strategies to teach science: inquiry and problem solving, collaborative learning, continual assessment embedded in instruction, and higher order questioning.
- Practice fair, consistent assessment for all students, and make sound inferences based on achievement data.
- Emphasize authentic instruction and elements that promote high performance and successful learning among students.
- Provide meaningful science learning for all students. (See the Critical Issue "Remembering the Child: On Equity and Inclusion in Mathematics and Science Classrooms.")
- Engage in effective professional development practices to deepen and build practice skills and strategies to understand student learning.
- Share professional learning with other colleagues on a continual basis.

Students:

- Be engaged in the learning process] and take responsibility for learning.
- Develop and demonstrate higher-order thinking skills.

- Relate knowledge from one scientific field to another and to other disciplines of knowledge.
- Acquire skills necessary for success in the workplace.
- Develop a genuine interest, excitement, interest, and appreciation for science and its interrelatedness with their personal lives.
- Reflect on their learning (using metacognition) to discover what learning and study strategies work best for them.

Parents:

- Utilize rich resources that their communities have to offer in helping their child through school
- Maintain ongoing conversations with teachers.
- Engage in scientific activities with their children at home.
- Seek training in ways to foster your child's learning.

IMPLEMENTATION PITFALLS:

Difficulties in Implementing the Science Content Standards. Along with many positive changes of systemizing the learning guidelines and expectations, the standards movement also has caused many challenges for educators. In most cases, standards are a starting point for curriculum development but often they are overly general and not ready for direct use in classrooms. In addition, the standards may require years of effort before they are achieved. Standards were created by advocates of a particular subject and when all are considered together, they present educators with the task of crowding into 12½ years what some experts believe is more than a 19-year expectation. As a result, standards are often addressed in a hit-and-miss fashion. At the Secretary's Summit on Science, Dr. Robert Tinker, president of the Concord Consortium, said "It's not just enough to have some new examples, some wonderful new Web sites, [or] some stuff peppered in …. We have plenty of resource s, but we lack a coherent, thoughtful, proven, tested curriculum" (U.S. Department of Education, 2004b).

Lack of Guidance in Addressing Additional Standards. Being aware of many reports on international comparisons such as TIMSS and PISA and the need for science and mathematically competent workers in our technological world, teachers have embraced the reform movement led by standards. Yet after the release of the *National Science Education Standards* , it was up to the individual classroom teacher to implement the standards. Many concerns immediately arose because the task seemed quite complex. It is extremely difficult for teachers to be successful in implementing the science content standards if they only concentrate on the subject matter standards of physical, life, and earth science. In addition to the processes of science involved using inquiry, scientific knowledge and reasoning, and critical thinking, the following categories of standards must be addressed:

- Standards for science teaching
- Standards for professional development for teachers of science

- Standards for assessment in science education
- Standards for science content
- Standards for science education programs
- Standards for science education systems (National Research Council, 1996)

Besides the obvious concerns about the science content itself as well as lack of guidance in standards implementation, the professional field is experiencing other roadblocks to success in student achievement. A few of such pitfalls include lesson-time scheduling, facility issues, professional development both for inservice teachers and preservice teachers, and a need for support from other stakeholders.

Difficulties in Lesson-Time Scheduling. Scheduling of time spent on science should be flexible and allow for extended sessions when necessary. There is no one scheduling model for all schools. The schedule must emphasize student learning and provide teachers time to plan and evaluate as well as meet collaboratively with each other. If the schedule does address these needs, it gives science teachers time to complete a lab activity in one sitting rather than interrupting the class and starting in the middle or all over again the next time the class meets.

Facility Issues. Besides scheduling, facility issues may be a concern for science teachers. Often, classrooms are overcrowded with students. In science especially, the issue of laboratory experience is critical. The National Science Teachers Association developed a Position Statement on Laboratory Science for various education levels: preschool/elementary, middle school, high school, and college. One of the recommendations is to have no more than 24 students per instructor.

Need for Ongoing Professional Development for Teachers. While all students must have an opportunity to become scientifically literate according to the science standards, teachers are professionals responsible for their own professional development. When seeking professional development, teachers must be cognizant of the fact that the science knowledge base changes rapidly and their students have diverse interests, needs, and experiences that must be addressed in instruction. Teachers also need opportunities to share professional development experiences with each other.

Need for Standards Instruction in Preservice Education. Besides the issues faced by inservice teachers, there are concerns regarding the preservice development that need to be addressed. The standards reform has presented a real challenge for methods instructors at institutions of higher learning. They not only must inform teacher candidates of reform recommendations but also must allow practicing teachers to input new ideas.

Need for Support from Other Stakeholders. Overall, stakeholders from many sectors of the education world need to be active in making effective changes in education. A recent report from the Education Commission of the States (Coble & Allen, 2005), written with the support of the National Science Foundation, indicated five key strategies for policymakers, university leaders, education researchers, and mathematics and science educators:

- Effectively assess student learning in mathematics and science.
- Strengthen teacher knowledge and skills in mathematics and science.
- Ensure that high-quality mathematics and science teachers are available to the most disadvantaged students.
- Ensure strong leadership from the higher education community, especially from university presidents.
- Promote public awareness of the importance of mathematics and science education in the country's future.

Addressing the Pitfalls

Texley (n.d.), a former editor of the National Science Teachers Association's *Science Teacher*, offered practical steps for teachers to take toward implementing the national science standards in the classroom:

- Look at your goals for the year.
- Look at the last year's lesson plans.
- Explore your students' preconceptions about new topics before they are introduced.
- Check students' understanding.
- Add a real-world extension to each laboratory or classroom experience.
- Look at the labs that are most successful for you.
- Reduce but don't completely eliminate direct, lecture-based instruction.
- Find ways to learn more about your students' differences in background, learning style, or opportunities to learn.

DIFFERENT POINTS OF VIEW:

Limited Impact of the Standards. Years after the publication of the national science standards, arguments are being made about the limited impact the standards have made.
At the Secretary's Summit on Science, Dr. George Pinky Nelson, director of Science, Mathematics and Technology Education at Western Washington University and a former astronaut, emphasized that standards have had a small yet slightly growing impact on the classroom:

> "To be perfectly honest, the impact of the standards in the classroom, I think, so far has been fairly small. The benchmarks—at least in the standards and in large part—were written with the idea of providing guidance for curriculum developers to develop materials, to develop professional development materials for teachers, and to guide university programs in preparing teachers to teach towards science literacy. Those materials are just now starting to emerge. One of the reasons Project 2061 was called Project 2061 was because it was expected to take a long time, and it is. So if we can stay the course, exponential growth is very slow at first, and I'm hopeful that in the next few years we are going to start seeing the fruits of that work making its way into the

classrooms, where we can start to see some real results with students." (U.S. Department of Education, 2004a)

Integration of Science Disciplines. Although many educators have embraced the science standards as they are, still others wish that the blending of the science disciplines would have occurred as was evident in early discussions of the writing process. The request for more "real world" was often stated. The fact that most teachers still teach the discrete disciplines of physics, biology, chemistry, and earth/space science may make the integration process more difficult.

Cross-Discipline Versus Departmentalization. Cross-discipline approaches to science are still not embraced by many elementary teachers. Many kids are curious about science events in their daily lives, so science can be used as a springboard to teach them other disciplines as well, such as mathematics and literacy. In general, middle school and high school teachers do not embrace this approach and prefer to remain tightly departmentalized.

Inquiry Versus Memorization. Rather than focusing on the processes of science, some teachers still think science is about memorizing facts. However, the inquiry involved in the processes of science benefits students by teaching them to problem-solve everyday routines and situations.

ILLUSTRATIVE CASES:

- **Lesson Study at Traverse City (Michigan) Area Public Schools**

Teachers from a school district in northern Michigan selected a specific science content standard as the goal of their Lesson Study. Their testimonials make reference to Lesson Study as a supportive professional experience that helps them better understand and sustain standards-based curriculum as well as promoting their own professional growth.

- **New Jersey Science Curriculum Framework**

Chapter 3 of the *New Jersey Science Curriculum Framework*, "Implementing a Standards-Based Science Curriculum," outlines the steps of implementing a standards-based science curriculum. It helps the school district, teachers, administrators, and curriculum developers trace a path that will guide all students to achievement in science.

- **Surveys of Enacted Curriculum**

The Surveys of Enacted Curriculum are research-based tools that collect, report, and use data on what content is taught and how it is taught. The tools—developed in 2003 by a collaborative of state specialists, content experts, education researchers, led by Council of Chief State School Officers, Learning Point Associates, and the Wisconsin Center for Education Research—allow educators to compare what is taught in the classroom to standards and assessments. The data are represented in scales and maps that can then be used to analyze instruction relative to curriculum, standards, and assessments. The Web site provides a description of a middle school using these tools in Connersville (Indiana) School District : Professional Development in Science

- **Understanding Science Project**

Initially funded by grants from the National Science Foundation and the Stuart Foundation to develop innovative solutions in science education, the Understanding Science Project, created by WestEd, develops nationally field-tested professional development resource s designed to help teachers learn major concepts of K–8 science, examine how children make sense of those concepts, and analyze and improve their teaching.

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National Center for Education Statistics
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Washington , DC 20006
202-502-7300
Web site: http://nces.ed.gov/

National Council of Teachers of Mathematics (NCTM)
1906 Association Drive

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Web site: http://www.nctm.org/

National Science Foundation
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Web site: http://www.nsf.gov/

National Science Teachers Association (NSTA)
1840 Wilson Boulevard
Arlington VA 22201-3000
703-243-3000
Web site: http://www.nsta.org

Additional Resources

- The National Staff Development Council keeps a list of its current professional development initiatives in specific content areas at NSDC projects.

- The National Science Teachers Association (NSTA) initiative Building a Presence for Science is intended to bring standards-based teaching and learning into schools and support the implementation of *National Science Education Standards* and state science standards. The initiative has established a network of science education leaders around the country to provide a wide array of services and materials for professional development aligned with standards.

- The Merck Institute for Science Education (MISE) has a mission to raise student interest, participation, and performance in science as well as to help students meet national and state standards. In the 1990s, it formed partnerships with four public school districts—three in New Jersey and one in Pennsylvania—to help students reach high levels of scientific literacy. The 10-year commitment resulted in findings related to professional development, leadership, culture and capacity change. Topic-specific reports are listed below:
  - *Changing District Culture and Capacity: The Impact of the Merck Institute for Science Education Partnership* (Corcoran & Lawrence, 2003)
  - *Getting It Right: The MISE Approach to Professional Development* (Corcoran, McVay, & Riordan, 2003)
  - *The Merck Institute for Science Education: A Successful Intermediary for Education Reform* (Corcoran, 2003)
  - *Teacher Leadership as a Strategy for Instructional Improvement: The Case of the Merck*

Institute for Science Education (Riordan, 2003)

- Curriculum Topic Study is a project funded by the National Science Foundation. The science book that has resulted from this project is *Science Curriculum Topic Study: Bridging the Gap Between Standards and Practice* by P. Keeley, published by Corwin Press in 2005. This publication presents a strategy to use the key national documents in science standards development and addresses student misconceptions, science content, and other issues to helps readers become better knowledgeable about a science topic. (More information is available at the Curriculum Topic Study Web site.)

- The National Science Teachers Association's July/August 2005 issue of *NSTA Reports* is titled "Information Technology's Role in 21st Century Science Education."

- The Board on Testing and Assessment offers resources relevant to K–12 assessment at Designing High-Quality Science Assessment Systems.

- Science.gov is a gateway to authoritative science information provided by U.S. government agencies.

- The Council of State Science Supervisors provides spreadsheets on state science assessment information, which offers information related to science assessment state-by-state, and state science frameworks and grade-level expectations, which provides links to state Web sites.

- The Teacher Quality Web site provides products, research, and services that promote teacher quality issues. It also offers a listing of resources for teacher quality.

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Date posted: 2005

Adobe Reader FAQ

Content and general comments: info@ncrel.org Technical information: pwaytech@contact.ncrel.org

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Return to " Science Education in the Era of No Child Left Behind—History, Benchmarks, and Standards."

Publishing of the *National Science Education Standards*

Inspired by the publication of *Science for All Americans* (Rutherford & Ahlgren, 1990) and the initial development of *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993), the National Research Council (a part of the National Academies) began development of national science standards in 1992. The council used these two publications as a foundation for the standards and indicated that the standards were appropriate for all students but were not meant to be a science curriculum. This idea was supported by many education professionals. As Resnick and Nolan (1995) had stated, "The challenge for the United States is to create a national agenda for excellence that can raise the performance of all students without creating a national exam or curriculum. Each community must adapt the agenda in unique ways that nonetheless work in unison" (p. 10).

Development of the standards was completed in 1995, and the National Research Council published the *National Science Education Standards* in 1996. The purpose of the publication was stated as follows:

"The *National Science Education Standards* present a vision of a scientifically literate populace. They outline what students need to know, understand, and be able to do to be scientifically literate at different grade levels. They describe an educational system in which all students demonstrate high levels of performance, in which teachers are empowered to make the decisions essential for effective learning, in which interlocking communities of teachers and students are focused on learning science, and in which supportive educational programs and systems nurture achievement. The *Standards* point toward a future that is challenging but attainable." (National Research Council, 1996, p. 2)

The publication is divided into two parts: (1) the content of science, and (2) the components of the education system that need to change to improve science education for all.

To build the foundational awareness level within the educational community, the National Science Teachers Association (NSTA) developed a position statement on the standards as well as a series of publications called *NSTAPathways to the Science Standards* , available for elementary, middle, secondary, and college levels. These four booklets, available on the NSTA's Teacher Resources: National Science Education Standards Web site are first steps to understanding the standards.

Besides attempts to understand the science standards, efforts have been made to pose key questions about the impact of national standards on education during the last two decades. The Committee on Understanding the Influence of Standards in K–12 Science, Mathematics, and Technology Education was formed. It was charged with the task of looking at the influence of standards in education and gleaning recommendations from the findings. In 2001, the committee reported its recommendations in

Investigating the Influence of Standards: A Framework for Research in Mathematics, Science, and Technology Education (Weiss, Knapp, Hollweg, & Burrill, 2001). The publication indicates a framework to reveal the influence of standards on mathematics, science, and technology education. It presents studies relevant to the standards, provides a conceptual tool for analyzing these studies, raises questions for future studies, and identifies gaps in current research.

In 2003, seven years after the publication of the *National Science Education Standards*, a workshop was held to review the evidence on the influence of the standards. During the workshop, titled "What Is the Influence of the National Science Education Standards? Reviewing the Evidence" discussions revealed that standards provided a vision statement to be used as a starting point for other organizations concerned with the improvement of science education. This vision statement provided states with a roadmap to use when creating their own standards, and "raised the debate" regarding the issue of science standards (Hollweg & Hill, 2003, p. 3). Among the workshop attendees were representatives from professional organizations of scientists and science educators, teachers, school district officials, teacher educators, researchers, curriculum developers, textbook publishers, government agencies, science centers, and museums. One workshop attendee cited the increased emphasis on inquiry in the science curriculum; another attendee pointed to the "strong influence" standards on professional development for teachers (Hollweg & Hill, 2003, p. 3).

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Return to " Science Education in the Era of No Child Left Behind—History, Benchmarks, and Standards."

The Benefits of Standards-Based Instruction

Standards-based instruction allows teachers and students to be on the same page by specifying how teachers and students will meet their education goals, including specific concepts, order, or instructional materials (Krueger & Sutton, 2001). Because the national science standards are voluntary and do not prescribe a single approach to teaching science, it is up to the individual local educational entities to determine the science content organization, focus, and delivery (Krueger & Sutton, 2001).

An example showing the value of standards-based instruction at the state level is Ohio's Academic Content Standards, which aim for a high and deep level of student understanding. These standards articulate the higher levels of learning for which teachers, schools, and districts are being held accountable through measures such as the expectations for a 21st century education, state testing, and report cards. By aligning classroom instruction and assessment with the standards, teachers can ensure that their students will meet these high demands. Teachers have the tools they need to track student performance and can plan focused instruction to meet the specific needs of all students.

An example showing the value of standards-based instruction at the school level is a Lesson Study team from Traverse City Area Public Schools (TCAPS) in Michigan. Through Lesson Study, teachers see first-hand the reasons why standards-based instruction is effective.

Eric Dreier, science coordinator for TCAPS, discusses the strong need to align national curriculum with state standards and the developmental level of students. [Video: :25]

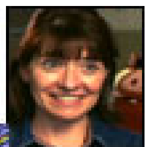
According to the *ENC Focus* issue titled "Looking Into a Standards-Based Classroom" (Eisenhower National Clearinghouse, 2004), a standards-based science classroom should have four embedded central strategies:

- Inquiry and problem solving
- Collaborative learning
- Continual assessment embedded in instruction
- Higher-order questioning

In standards-based instruction, standards delineate what matters, provide clarity and a fixed point of reference for students and teachers, guide instruction so that it is focused on student learning, provide a common language to have conversations, help ensure equal educational opportunities, assist in identifying struggling students, and meet federal guidelines (Ohio Department of Education, n.d.). At the Secretary's Summit on Science, Barbara Morgan, a teacher-astronaut, stated that standards provide a strong focus for learning:

> "I think the standards have helped focus the curriculum so that there is more across the schools and up and down the grade levels. We have an understanding of the content we want kids to learn, but I think we have a long way to go in how the students best learn it and how we get them excited about learning." (U.S. Department of Education, 2004a)

Demonstrating student learning is a complex task for teachers. Teachers need professional development opportunities to develop their own understanding of science and their understanding of how students learn science. Although standards help educators take a step towards a set of common goals, these statements do not tell teachers if the standards are effective nor do they provide guidelines for effective instruction. Appropriate professional development is necessary to support teacher learning that focuses on student outcomes.



Kathy Johnston, a fourth-grade mathematics and science teacher at Oak Park Elementary School in Michigan, talks about Lesson Study as a professional development approach that helps her see students learning and enables her to develop instructional strategies to advance student understanding. [Video: :30]

Standards-based reform has many curricular and instructional prerequisites. According to Stanovich and Stanovich (2003), teachers are required to use specific knowledge and skills to know what works in science education:

> "The curriculum must represent the most important knowledge, skills, and attributes that schools want their students to acquire because these learning outcomes will serve as the basis of assessment instruments. Likewise, instructional methods should be appropriate for the designed curriculum. Teaching methods should lead to students learning the outcomes that are the focus of the assessment standards." (p. 1)

Knowing what works in education requires teachers be knowledgeable about research-based materials. The What Works Clearinghouse was established in 2002 by the U.S. Department of Education's Institute of Education Sciences to provide educators, policymakers, researchers, and the public with a central and trusted source of scientific evidence of what works in education. The clearinghouse currently is featuring research studies on mathematics middle school curricula, with science to follow next.

References

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Abbey Leppien:
Instructional Decisions and Student Assessment

Abbey Leppien

Fourth-fifth Grade Teacher
Bertha Vos Elementary School
Traverse City Area Public Schools

VIDEO TRANSCRIPT:

I think the biggest thing is that I realize that every child needs to succeed. I've always wanted all of my students to succeed, but this is really making me kind of reevaluate how I go about teaching. If I did it in a whole-class format before, maybe I'm breaking that up and doing some small-group [work] and that gives me an opportunity to move around and work with each child and kind of check in with them. Also, it helps me to [improve]. I've realized that higher order thinking and that deductive reasoning are very important. So [I'm] working on the thought processes through that and talking about that, doing think-alouds, and kind of changing up my style of how I approach some of the teaching that I do.

Eric Dreier:
Standards-Based Assessment

Eric Dreier

District Science Coordinator
Traverse City Area Public Schools

VIDEO TRANSCRIPT:

The standards-based piece gives you a direct focus. Now we match up where our students are meeting standards, where are they not, and then of course there's a whole long list of subsequent questions to that in terms of why aren't they meeting that, what could be the problems, how do you analyze those, and how do you go ahead and build capacity to help people do that. So it's been a blessing in the regard that I think it has provided us a bull's eye that we continually try to look at and meet.

Lesson Study as a Professional Development Strategy

Since its U.S. introduction in the late 1980s, Lesson Study has rapidly become a professional development of choice for school districts across the country. A database from the Lesson Study Research Group (n.d.) housed at Columbia University Teachers College lists Lesson Study groups in 33 states. More than 800 individuals subscribe to the Lesson Study electronic mailing list.

Originating in Japan, Lesson Study was presented to U.S. educators as a compelling strategy for meaningful professional development, yet was found to be adaptable to the exigencies of different cultural settings. Now, in its growth phase, Lesson Study often is referenced in the current literature as a model of professional development with particular local flavors (McLaughlin & Yocom, 2005). A listing of research literature is available at Lesson Study Articles/Papers. Detailed descriptions of the Lesson Study process can be found in two issues of *Northwest Teacher* magazine titled "Lesson Study: Teachers Learning Together" and "Lesson Study: Crafting Learning Together".

Because different approaches and adaptations of Lesson Study are being implemented around the country, it is important to highlight the core features that make this strategy one of the most powerful professional development experiences. At the heart of the Lesson Study process lie the key qualities of professional development standards:

- Students are at the center of this process.
- Teachers have the opportunity to develop their own knowledge and skills.
- Teachers learn collaboratively, while focusing on a few ideas.
- The process honors teacher knowledge as well as contributions from outside experts.
- The process supports alignment with standard-based curriculum.

In Lesson Study, teachers join together to plan, observe, teach, and debrief a lesson, frequently referred to as the "research" lesson. Throughout the process, the Lesson Study team focuses on understanding student learning.

For more information, refer to Lesson Study at Traverse City (Michigan) Area Public Schools .

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Adobe Reader FAQ

Lesson Study at Traverse City (Michigan) Area Public Schools

Teachers from a school district in northern Michigan selected a specific science content standard as the goal of their Lesson Study. The teachers' comments make reference to Lesson Study as a supportive professional experience that helps them in understanding and sustaining a standards-based curriculum as well as promoting their own professional growth. The comments are organized according to the characteristics of Lesson Study that teachers found to be useful.

Planning and Improving Lessons. One characteristic of Lesson Study is that it helps teachers plan and improve lessons.

Karen Nelson, a teacher at Eastern Elementary School in Michigan, talks about using Lesson Study to plan lessons collaboratively. [Video: :35]

Robin Brister, a fourth-grade teacher at Norris Elementary School in Michigan talks about using Lesson Study to develop lessons. [Video: :43]

Deeper Understanding of Science Teaching and Learning. In addition to helping teachers plan and improve lessons that focus on a specific content standard, the Lesson Study process helps teachers develop their own understanding of the content, which in this case is science.

Abbey Leppien, a fourth-fifth grade teacher at Bertha Vos Elementary School in Michigan, talks about how appropriate professional development intertwined with standards-based instruction has helped her gain a deeper understanding of science teaching and learning. [Video: :50]

Lesson Study, however, is not just for science content. Kristin Sak, fourth-grade teacher at Bertha Vos Elementary School in Michigan, says that Lesson Study carries over to other academic areas and especially is valuable for ensuring that content makes the connections to the real world for students.

Focus on the Learner. Another characteristic of the Lesson Study is its focus on learners rather than teacher behaviors. Lesson Study keeps students at the center of this inquiry process. By focusing on what students need to know and be able to do, science standards serve as guidelines to help teachers define the student outcomes, frame observations, and reflect on accomplishments and improvements.

Robin Brister, a fourth-grade teacher at Norris Elementary School in Michigan, discusses the focus on student understanding. [Video: :35]

Collaboration. An important feature of the Lesson Study process is collaboration. Lesson Study teams offer teachers opportunities to learn from each other. Teachers who participate in Lesson Study teams speak highly about the experience of job-embedded learning about science knowledge and science content, supported by their colleagues' expertise and the contributions of knowledgeable others.

Linda Egeler, a fourth-grade mathematics and science teacher at Cherry Knoll Elementary School in Michigan, discusses the collaboration inherent in Lesson Study. [Video: :34]

Ongoing Teaching and Learning. Because the purpose of Lesson Study is to engage in ongoing inquiry about teaching and learning rather than arriving at the perfect lesson, sharing and trust is critical. Teachers who participate in Lesson Study benefit from the opportunity to engage in ongoing learning, explore new ideas, and try them out in the company of a supportive group of colleagues.

Linda Egeler, a fourth-grade mathematics and science teacher at Cherry Knoll Elementary School in Michigan , is appreciative of the power of the collaborative learning community built around Lesson Study and the feeling of trust and sharing among her colleagues. [Video: :39]

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Eric Dreier: Benefits of Standards-Based Instruction

Eric Dreier

District Science Coordinator
Traverse City Area Public Schools

VIDEO TRANSCRIPT:

The big benefit that we see is obviously the improvement of instruction. And, therefore, it improves our capacity and our capability of learning with children. We also see a very substantial benefit in having our teachers work together collaboratively on a common focus topic in an area where we know that there can be deficiencies in the lesson. We've appreciated the focus that it has afforded us in looking at deficiencies in lessons and curriculum, rather than on the teaching itself or on the teacher.

Another piece to this, we found, is even though we do have nationally recognized curriculum units, those have not necessarily been suitable for our state standards, nor have they in all cases been really suitable for students at a particularly developmental age level. Then there's a secondary benefit that we've really appreciated and that is: there's the symbolic as well as the substantive message that our district sends to teachers when they provide support for problems the teachers have that are real classroom problems.

Kathy Johnston: Lesson Study and Student Outcomes

Kathy Johnston

Fourth Grade Teacher
Oak Park Elementary School
Traverse City Area Public Schools

VIDEO TRANSCRIPT:

I think [Lesson Study] has helped me to focus in exactly on what the kids are thinking. Try as hard as we might, we don't know how they think. And seeing the process, actually watching kids go through a lesson, trying to anticipate what they're going to have misconceptions about, but then actually seeing them do it—and we may be off but we may be on—and just seeing what they actually get out of it, and seeing if they do meet the standard that we were trying to meet.

Understanding Science Project

Initially funded by grants from the National Science Foundation and Stuart Foundation to develop innovative solutions in science education, the Understanding Science Project at WestEd develops nationally field-tested professional development resource s designed to help teachers learn major concepts of K–8 science, examine how children make sense of those concepts, and analyze and improve their teaching.

Since its beginnings in 1998, the project has reached more than 500 teachers (impacting an estimated 12,000 students). At present, the program consists of content courses for elementary teachers, each on a different topic and grade span (for example, electric circuits in Grades 3–5). Courses for middle school teachers are being developed. The full set of Understanding Science courses will make up a comprehensive professional development curriculum, including 15 courses on the major ideas of earth, life, and physical science.

Course materials include narrative cases drawn from actual classroom episodes and focus on three key qualities of masterful science teaching: knowledge of science, knowledge of learners, and knowledge of teaching. An extensive, multiyear study has shown that Understanding Science courses build teacher knowledge, strengthen classroom practice, and positively impact student achievement. The most dramatic increases were among low-performing students.

For more information, refer to the Understanding Science Project.

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Karen Nelson: Lesson Study

Karen Nelson

Fifth Grade Teacher
Eastern Elementary School
Traverse City Area Public Schools

VIDEO TRANSCRIPT:

Lesson Study is a real collaborative, working together. I found out about it about three years ago, and I knew nothing about it, and I went in not knowing anything about it. And it is a great way to sit down with other people that teach the same thing that you're teaching to help you write a lesson that needs to be in place. Either the kids have misconceptions, or there's a hole in your curriculum, or the new mandates from the state have shifted things. And you don't have anything to take care of it, and you work collaboratively to write a lesson that ends up working for everybody. And you also have everybody's brain to think about when you're doing it, so it's not just on your shoulders.

Robin Brister: Lesson Study

Robbin Brister

Fourth Grade Teacher
Norris Elementary School
Traverse City Area Public Schools

VIDEO TRANSCRIPT:

Lesson Study is a chance to take a lesson that we're questioning or that we're having difficulty with and look at—putting it under a microscope. For some reason, our students aren't performing or understanding what we're expecting them to so we try it out with different classes, and we try to revise the lesson so that we're able to access the students' understanding. Whatever we've been doing hasn't been accessing what we need from them. So it's a chance for us to get together and talk and learn from our students how we can improve this lesson.

Abbey Leppien: Instructional Decisions and Student Assessment

Abbey Leppien

Fourth-fifth Grade Teacher
Bertha Vos Elementary School
Traverse City Area Public Schools

VIDEO TRANSCRIPT:

I think the biggest thing is that I realize that every child needs to succeed. I've always wanted all of my students to succeed, but this is really making me kind of reevaluate how I go about teaching. If I did it in a whole-class format before, maybe I'm breaking that up and doing some small-group [work] and that gives me an opportunity to move around and work with each child and kind of check in with them. Also, it helps me to [improve]. I've realized that higher order thinking and that deductive reasoning are very important. So [I'm] working on the thought processes through that and talking about that, doing think-alouds, and kind of changing up my style of how I approach some of the teaching that I do.

Robin Brister: Lesson Study

Robbin Brister

Fourth Grade Teacher
Norris Elementary School
Traverse City Area Public Schools

VIDEO TRANSCRIPT:

I was thrilled. Because I've done some similar things like this before, and I don't think we have enough time to do this. I love the chance to talk with students—with teachers—and to listen to my students, have everybody discuss it. I love the time that's involved. It's a long time and it seems like a lot of time to just look at one lesson. But what I like about it is it benefits everybody in the whole district. It benefits all the students in the district, and it benefits whatever I'm going to be teaching for the next few years.

Our intent is to fix this lesson so that we access students' understanding better and then can share it with everyone else so then they can use it.

It really keeps my teaching true and, and it makes it stay tied to the standards rather than being something that I kind of teach on my own.

Linda Egeler:
Power of Collaborative Learning

Linda Egeler

Fourth Grade Teacher
Cherry Knoll Elementary School
Traverse City Area Public Schools

VIDEO TRANSCRIPT:

I liked the process in that it was a great team. There was a lot of discussion, give and take, with members. Right away, the trust was there so that even as I was teaching today in front of the teachers, I didn't feel intimidated. I felt that [it] was my support group, as opposed to someone who might be critical of me. And every teacher had different ideas and, we had many discussions about, you know, 'I do it this way' and 'I do it this way'—what would work better? And even throughout the course of the unit, I did try different strategies that I gleaned from other people to see which one works with my particular group and just thought it was a wonderful process.

Linda Egeler: Benefits of Colleagues' Expertise

Linda Egeler

Fourth Grade Teacher
Cherry Knoll Elementary School
Traverse City Area Public Schools

VIDEO TRANSCRIPT:

I think it's critical. Because when you're in your own classroom, you shut the door [and] you do your own thing. And it's very easy to get caught up in your comfort zone and to repeat the same sort of thing year after year. Whereas the Lesson Study, again, makes sure that you're referring to standards and benchmarks and, you know, from year-to-year and if those ever change, you would be aware of that. But mostly it's the input from the other teachers that's important to me, and they talk about what works and what doesn't. And invariably I think you can always find a way to improve your own instruction. There's always great advice from a team.