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Successes and Continuing Challenges: Implementing the Changes in Professional Development for Teachers in the U.S.

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Abstract

The 1996 National Education Science Standards (NSES) in the U.S. provide descriptions of needed reforms for K-16 science teaching and improvements regarding indications of student learning. The goals indicate specifically the changes needed in teaching and improved ways for assessing student learning. This paper discusses how teaching and student assessment have changed the professional development and ways of accomplishing better learning with students. The emphasis is on teacher preparation and continuing work with in-service teachers which has improved U.S. teachers. It is important to note how such changes can provide additional evidence for accomplishments while also encouraging additional changes.

Key Words: Science Teaching, Assessment, Student Learning

Introduction

Fifteen years have elapsed since the 1996 publication of the National Science Education Standards (NSES) (NRC 1996). There are many critical issues in science education that remain. These include: How far have we progressed in putting the visions of the NSES into practice? What remains to be done? What new visions are worthy of new trials?

Several of the NSTA Exemplary Science Monographs seek to answer these questions. These include: 1) Exemplary Science in Grades PreK-4; 2) Exemplary Science in Grades 5-8; 3) Exemplary Science in Grades 9-12; 4) Exemplary Science: Best Practices in Professional Development; 5) Inquiry: The Key to Exemplary Science; 6) Exemplary Science in Informal Education Settings; 7) Exemplary Science for Resolving Personal and Societal Challenges; 8) Exemplary Programs for building Interest in STEM Careers; 9) Exemplary College Science Teaching: Helping or Hindering STEM Reforms; and 10) Exemplary STEM Programs: Designs for Success (in progress). Of course, the monograph entitled “Best Practices in Professional Development” is of great importance. It is always exciting to think of science teachers always continue to improve – based on evidence that they help to provide. Other monographs of importance are the grade level ones, namely: 1) Exemplary Science in Grades PreK-4; 2) Exemplary Science in Grades 5-8; and 3) Exemplary Science in Grades 9-12 which indicate successful changes.

How Exemplars are Chosen

The Exemplary Program series was conceived in 2001 by an advisory board of science educators, many of whom had participated in the development of the National Science Education Standards. The advisory board members (who are all active and involved NSTA members) decided to seek exemplars of the NSES *More Emph*asis conditions as a way to evaluate progress toward the visions of the NSES. The *More Emphasis* conditions provide summaries of the NSES in science teaching, professional development, student assessment, and a broad view of science content, and whole school programs that are needed for reform efforts, i.e., not just science alone. The board sent information about the projected series to the NSTA leadership team and to all the NSTA affiliates, chapters, and associated groups. A call for papers describing exemplary programs also appeared in all NSTA publications. In addition, more than a thousand letters inviting nominations were sent to

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leaders indicated from the NSTA Handbook. Further, personal letters were sent to leaders of all science education organizations.

After preliminary responses were received, the advisory board identified teachers and programs that it felt should be encouraged to prepare formal drafts for further review and evaluation. The goal was to identify at least fifteen of the best situations of each of four areas – professional development and grades PreK-4, 5-8, and 9-12—where facets of the teaching, professional development, assessment, and content standards were being met in an exemplary manner.

The most important aspect of the selection process was the evidence the authors for each chapter could provide regarding the effect of their programs on student learning. This aspect proved the most elusive. Most of us "know" when something is going well, but we are not well equipped to provide real evidence for this "knowing". Many exciting program descriptions were not among the final titles—simply because little or no evidence other than personal testimony was available in the materials forwarded. The sixteen professional development models that make up a particular monograph were chosen by the NSTA advisory board as the best examples of models that fulfilled the *More Emphasis* conditions of the Professional Development Standards; each has had a clear, positive impact on student science learning. The most important efforts, for change, include teaching and assessment of student learning. The following include the features: Teaching Standards: understanding and responding to individual student's interests, strengths, experiences, and needs; selecting and adapting curriculum; focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes; guiding students in active and extended scientific inquiries; providing opportunities for scientific discussion and debate among students; continuously assessing student understanding (and involving students in the process); sharing responsibility for learning with students; supporting a classroom community with cooperation, shared responsibility, and respect; and working with other teachers to enhance the science program: Student Assessment Standards: assessing what is most highly valued; assessing rich, well-structured content; assessing scientific understanding and reasoning; assessing to learn what students do understand; assessing achievement and opportunities to learn; students engaged in ongoing assessments of their work and that of others; and teachers work to improve on what they often cannot determine.

The History of the National Science Education Standards

Most educators credit the National Council of Teachers of Mathematics (NCTM) with initiating the many efforts to produce national standards for programs in U.S. schools. In 1986 (10 years before the publication of the National Science Education Standards), the board of directors of NCTM established a Commission on Standards for School Mathematics with the aim or improving the quality of school mathematics. An initial draft of these standards was developed during the summer of 1987, revised during the summer of 1988 after much discussion among NCTM members, and finally published as the Curriculum and Evaluation Standards for School Mathematics in 1989. All of this was done without financial support beyond NCTM – something that has not been done again as interest and support from such efforts received attention and financially support.

The NCTM standards did much for mathematics education by providing a consensus for what mathematics should be. The National Science Foundation (NSF) and other funding groups had not been involved in developing the math standards, but these groups quickly funded research and training to move schools and teachers in the direction of those standards. Having such a "national" statement regarding needed reforms resulted in funding from private and government foundations to produce school standards in other disciplines, including science.

NSF encouraged the science education community to develop standards modeled after the NCTM 1989 document. Interestingly, both the American Association for the Advancement of science (AAAS) and the National Science Teachers Association (NSTA) expressed interest in preparing science standards. Both organizations indicated that they each had made a significant start on such national standards – AAAS with its Project 2061 and NSTA with its Scope, Sequence, and Coordination project. Both of these national projects had significant support from NSF, private foundations, and industries. The compromise on this "competition" between AAAS and NSTA leaders led to the recommendation that the National Research Council (NRC) of the National Academy of science be funded to develop the National Science Education Standards. With NSF funding provided in 1992, both NSTA and AAAS helped to select the science leaders who would prepare the NSES. Several early drafts were circulated among hundreds of people with invitations to comment, suggest, debate, and assist with a consensus document. A full-time director of consensus provided leadership and assistance as final drafts were assembled. It took over $7 million and four years of debate to produce the 262-page NSES publication in 1996.

There was never any intention that the Standards would indicate minimum competencies that would be required for all. Instead, the focus was on visions of how teaching, assessment, and content should be changed. Early on, programs and systems were added as follow-ups to teaching, assessment, and content and thereby comprising the Standards. Most concentrated on content – which all too often is all that is undertaken for reform efforts.

The NSES volume begins with standards for improved teaching. That chapter is followed by chapters on professional development, assessment, science content, and school programs and the whole system. Content was placed in the document after the first three for fear that placing it first would invite a focus only on what should be taught – almost relegating teaching, development, and assessment to "add-on" roles. Nonetheless, the major debates centered on what should appear in the content section.

It is interesting to note that the early drafts of the National Science education Standards did not include any mention of professional development. It was only when the final draft was about to be offered to the leadership in the National Academy of Sciences that a section on professional development was added. This addition came in response to the argument that such visions for the continued education of teachers would be needed if any significant use of the Standards, any improvement for in-service teachers, and any improved ways of preparing new teachers could to be realized. They were added as a way of ensuring that the science teaching standards would be central in the preparation of new teachers as well as continuing education of all in-service teachers.

The Four NSES Goals for School Science

An exemplary professional development program must prepare teachers to implement the four NSES goals for school science, which are to educate students to be able to:
Goal 1: experience the richness and excitement of knowing about and understanding the natural world;
Goal 2: use appropriate scientific processes and principles in making personal decisions;
Goal 3: engage intelligently in public discourse and debate about matters of scientific and technological concern; and
Goal 4: increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers (NRC, 1996, p. 13).

A look at each of these goals is important for professional development as we all wonder how far along we have advanced to meet them in today's science classrooms.

Goal 1: For many educators, the first goal is the most important science it ensures that every student will have a firsthand, personal experience with the whole scientific enterprise. This means exploring nature with the natural curiosity that all humans enjoy. It means asking questions, identifying the unknown, proceeding to knowing – even if what results is a personally constructed answer or explanation that might be wrong in terms of current science notions. What matters is that personal curiosity sparks an original question.

Unfortunately, science educators sometimes define science as the information found in textbooks for K-12 and college courses as the content outlined in state frameworks and standards. Such definitions omit most of what George Gaylord Simpson (1969) described as the essence of science. Simpson held that five activities define science:

1. asking questions about the natural universe; i.e., being curious about the objects and events in nature;
2. trying to answer one's own questions; i.e., proposing possible explanations;
3. designing experiments to determine the validity of the explanation offered;
4. collecting evidence from observations of nature, mathematics calculations, and whenever possible, experiments carried out to establish the validity of the original explanations;
5. communicating the evidence to others who must agree with the interpretation of the evidence in order for the explanation to become accepted by the broader community [of scientists]. (Simpson, 1969, p. 81)

These five activities are rarely carried out in schools. Science students seldom determine their own questions for study; they are not expected to be curious; they rarely are asked to propose possible answers; they seldom are asked to design experiments; and they rarely share their results with others as evidence for the validity of their own explanations (Weiss et al. 2003).

Overall, one could argue that "real" science is seldom encountered or experienced at all in most science classrooms. The typical focus is almost wholly on what current scientists accept as explanations (Harms and Yager, 1981; Weiss et al., 2003). Competent science students only need to remember what teachers or textbooks say. Most laboratories are but verification activities of what teachers and textbooks have indicated as truths about the natural world. There is seldom time for students to design experiments that could improve human existence.

Goals 2, 3, and 4. The other three goals from the Standards focus on experiences in school science that affect the daily lives of students, helping them to make better scientific and societal decisions and leading them to increased economic productivity. Regrettably, these three goals are rarely approached, realized, or assessed in typical classrooms by typical teachers. Information that would help in realizing these goals is not offered in texts, teacher preparation efforts, or programs for in-service teachers. If we want science concepts and skills to be used in making personal decisions, we are going to have to deal with ideas of how these goals can be achieved. In Understanding by Design, Wiggins and McTighe (1998) provide ideas about what needs to be done – in particular, what evidence we need to collect to be sure we have met Goal 2 (i.e., using appropriate scientific methods and principles for making personal decisions). We cannot stop with the idea that students seem to know certain concepts and can perform certain skills. We need to expect evidence for learning to include practice with the concepts and skills in actually making decisions for daily living.

Regarding Goal 3, educators must focus on involving students in public discourse and debate in school, as well as in the outside community. Where do they actually use what is in the curriculum and what teachers teach? A whole new way of viewing content, instruction, and assessment is needed if this goal is to be realized. Goal 4 may be the most difficult to achieve and to assess. In some ways it is further from daily life and the immediate community than the other goals. It focuses on future economic productivity, possible career choices, and the use of concepts and processes that are often given short shrift in today's science classrooms.

Professional Development and the Standards

Professional Development is about ensuring that teachers continue to grow and improve. Professional Development forces us to look at the acts of teaching and to discuss the effects of these acts on student learning. We have to be sure that real learning does result and that it is learning with understanding and potential use – not merely an indication of students' ability to remember, repeat, and recite.

Professional Development Challenges and Solutions

Professional Development providers need to be familiar with how content strands are organized across K-12 curricula and how major concepts and processes are seen and used in concert. Professional Development initiatives must focus on science as inquiry and on how science teaching also can result in inquiries about teaching. If we focus too acutely on a single scientific discipline, and exclude concepts from other disciplines, problems result.

Another serious issue is that schools too often spend funds on general workshops with leaders from general education backgrounds. The workshops are basically speeches presented to all teachers in a building or district, without regard to the likely impact of their implementations for daily teaching, the curriculum, or student learning. In addition, staff development efforts often present an abundance of suggestions for reform – too many to be carried out over a relatively short period of time.

Furthermore, professional development programs are often structured solely as a summer workshop or institute. Even those lasting over multiple weeks focus only on "more science study", with little attention paid to how new information and insights can be used successfully to promote more and better student plans and experiences. Recent evidence suggests that work with in-service teachers should be extended to plans for actual changes to be tried during the following academic year. Teachers should have opportunities to practice "evidence collecting" to determine the impact of what they have learned in the summer workshop or institute on their students (Weiss et al., 2003). Evidence suggests that in-service work is more effective the longer it is sustained – and continued over three, four, or even more sequential years. (SUNY, 1996, Chapter 27)

Among issues at the college level is the fact that although 50 semester hours of course work in science certainly indicates a strong background in traditional science, it is no indication of someone's ability to teach. And too often, science methods courses are taught in the same way that science is taught: Instructors define terms, provide lists of ways to teach, offer their own ideas, and expect students to take notes and repeat what they say for tests. This approach is no better than what typically happens in science classrooms and laboratories. We have learned more about how people learn in the last decade (see, e.g., Bransford, Brown, and Cocking, 1999) than can be considered in a single, three-semester-hour methods course.

Changes Needed

The 16 exemplars described in the ESP monograph focusing on Professional Development provides very creative ideas with all kinds of evidence that progress is being made toward carrying out the visions of the NSES. They each illustrate important contexts for assisting with the preparation of new science teachers and for assessing the continual growth and development of in-service teachers. Staff development should always be planned so that teachers become enthusiastic about the NSES and are ready to implement the visions which are recommended.

The exemplary programs described in the NSTA ESP monograph illustrate the progress that science education has made in meeting the Professional Development Standards in the National Science Education Standards (NRC, 1996). In addition, descriptions of these programs for teachers in preparatory progress and teachers in the field demonstrate how well the *More Emphasis* conditions of the Teaching Standards, Assessment Standards, and Content Standards have been met.

Of particular interest is that the programs the NSTA Advisory Board selected for publication have addressed all the professional development *More Emphasis* conditions in exemplary fashions. Only one of these conditions fell below a 75% success rate. This one condition – basing the teacher in the role of a "producer of knowledge about teaching" – is arguably an issue we should work harder toward achieving. Perhaps more attention should be paid to the Lesson Study initiative (development and practiced in Japan) that is being used in many regions across the United States. The professional development *More Emphasis* conditions with the greatest and most focused implementation are (1) "collegial and collaborative learning", (2) "teachers as members of a collegial and professional community", (3) developing "long-term, coherent plans", and (4) "teachers as an intellectual, reflective practitioners".

An analysis fo the implementation of *More Emphasis* conditions for the Teaching Standards gives clear, positive evidence of change. Of the nine *More Emphasis* conditions concerning teaching, the only one that was not approached by at least 60% of the programs was the teacher's role in "selecting and adapting curriculum". Conversely, the most success was reported in "supporting a classroom community with cooperation, shared responsibility, and respect". It is certainly significant that the exemplary programs in professional development are so successful in changing teaching in ways that the Standards envision.

The exemplary programs for professional development were also successful in meeting the States Assessment Standards. The seven *More Emphasis* conditions of the Assessment Standards were met in a positive fashion, resulting in teachers who understood and used these new guidelines and who understood their value for ensuring student learning. Just as was the case with the *More Emphasis forTeaching* conditions, the one weakness in the assessment area for the professional development providers discussed in the NSTA ESP monograph was developing teachers who could either be involved in preparing external assessments or be invited to assist with such assessments. This is one issue where more work must be undertaken. We need to increase the involvement of teachers committed to the visions of the Standards in the preparation of external assessments. Too often in the past, those who produce such assessments have assumed that their job was to devise tests that reflect what teachers are doing in their classrooms – not what teachers should be doing if they are implementing the recommendations of the National Science Education Standards.

Most of the exemplary professional development programs also focused on the definition and description for science content (including a focus on inquiry) found in the Standards. The authors used the general content descriptions and reported major successes. We do need to note, however, the lack of success with four *More Emphasis* conditions from the Content Standards. These were not even in evidence for over a third of the exemplars. These areas of continuing weakness are:

1. using evidence and strategies for developing or revising an explanation;

2. science as argument and explanation;
3. doing more investigations in order to develop understanding, ability, values of inquiry, and knowledge of expanded views of science content; and
4. applying the results of experiments to scientific arguments and explanations. (NRC, 1996, p. 113)

Failure to focus on and emphasize these four conditions suggests a need for more attention to the meaning, history, sociology, and psychology of science. Lack of attention to these areas has been a weakness in teacher education programs, where there has been almost total emphasis on content knowledge (almost exclusively in disciplinary contexts) and on learning theory and pedagogy.

Furthermore, too many educators think of *science* only as life, physical, and earth/space—and pay little or no attention to the other four facets of content as defined in the National Science Education Standards (including inquiry, technology and its relation to science, science as a means of meeting social challenges, and the history and philosophy of science). There is too little indication that they indicate exemplary professional development programs identified which have moved far enough toward this broader view of science content. An analysis of how well the *More Emphasis* conditions have been met by the 16 exemplary programs produces exciting results at an 80% success rate. Perhaps programs such as the ones identify in the NSTA ESP efforts will succeed in future years, with more showing up in the remaining 20%.

Conclusions

Many of the teachers involved with the production of the Standards suggest that it would take at least 10 years to achieve the visions that inform the recent results. The hope is that other educators will take the ideas described and develop other programs for teachers in continued progress as well as in-service teachers that include mechanisms for collecting evidence of change with respect to all the *More Emphasis* conditions. Perhaps the New Standards (2013) will result in even more exemplary programs. Certainly the greater focus on technology and engineering will be a difficult fete to accomplish. Too many leaders and educators in general view science – especially in high schools as life, physical, and earth science exclusively.

More effort is needed when one considers that there are nearly 1,300 colleges and universities which preparatory programs for science teachers in the U.S.. One cannot help but wonder if some of these programs should not combine, so that the numbers enrolled justify a program with all the features demanded by the Standards. It is also apparent that most of the funding for professional development of in-service teachers must be directed more toward the full visions of national standards (including the standards of the National Council of Teachers of Mathematics, the International Technology Education Association, and the Next Generation Science Standards in the U.S.) if we are going to be as successful as we need to be in the next several decades. We need to rethink the ways to teach science and how it appears in books which can help us all meet the realizations of the visions – perhaps in less than the 75 years envisioned by the Project 2061 leaders (AAAS, 1990).

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