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Are We Missing the Essence of the Visions Central to the U.S. National Science Education Standards (NSES)?

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ABSTRACT

Standards for teaching science in all schools were released in 1996 after four years of debate that included scientists and educators across the U.S. This study is a review of each section of these National Standards which provide specific visions for change from the status quo. Identifying current practices and recommending specific changes for teaching, staff development, assessment, content, and features needed for implementation are outlined and contrasted. Most of the recommendations remain as "efforts-in-progress"; more work and collaboration among professionals are needed if the stated goals are to be met.

Keywords: National Standards; Goals; Less/More Emphasis.

INTRODUCTION

After some introductory chapters in the U.S. National Standards, there are six chapters that include the essence of the Standards for Pre-K through 12 science in U.S. schools. These six chapters include: teaching, professional development, assessment, content, programs, and systems. Each of these chapters closes with a summary indicating Less Emphasis and corresponding More Emphasis conditions. In a very real sense these changes, i.e., "less or more" indicate clearly and contrast "the" visions conceived in the document that took four years to develop at the expenditure of $7 million dollars. The Less Emphasis conditions represent what is practiced in too many traditional schools. The More Emphasis conditions in the six chapters provide a summary of the specific visions for change that are recommended. Why are not these visions more central to our reform efforts of the 21st Century? Is the science leadership aware of and in agreement with the reforms which took so long to produce?

The More Emphasis visions for teaching, professional development, assessment, content, programs, and systems were preceded with an elaboration of the "goals" for science education in U.S. schools which should be considered prior to looking at the summaries at each of the six chapters. These goals indicate that all students should:

1. Experience the richness and excitement of knowing about and understanding the natural world;

2. Use appropriate scientific processes and principles in making personal decisions;

3. Engage intelligently in public discourse and debate about matters of scientific and technological concern; and

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)

Changes Needed in Science Teaching

The "teaching" chapter is included first with the summary at the end of the chapter indicating the needed changes. Teaching was placed first because of its importance. Certainly, for me and many others, teaching embodies the key for accomplishing the needed reforms! Too many efforts of reform start and end with experts and/or governments producing curricula which outline what teachers should do to accomplish better student learning. But, changes in teaching are drastically needed with a rationale and a model for others to see. It should be an insult for professional teachers to be given "teacher-proof" materials to use with students – assuming that the reforms could be accomplished if only the prepared materials were used and followed with hints to teachers in teacher guides. Government officials are usually unprepared and should not "direct" reform efforts!

There are nine visions for the changes of teaching that if implemented and used would accomplish more successes with student learning and general reforms in science classrooms around the world.

Another reason for teaching preceding all else in the National Standards is that there were no debates regarding the proposed changes. They did not upset any of the thousands who helped develop the "Standards". Perhaps this lack of disagreements occurred because the scientists involved were more concerned with specific content to be used in classrooms and cared less about teaching – or, even recognizing its importance! The nine changes envisioned for changing science teaching are:

Less Emphasis On	**More Emphasis On**
1.Treating all students alike and responding to the group as a whole	Understanding and responding to individual student's interests, strengths, experiences, and needs
2.Rigidly following curriculum	Selecting and adapting curriculum
3.Focusing on student acquisition of information	Focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes
4.Presenting scientific knowledge through lecture, text, and demonstration	Guiding students in active and extended scientific inquiries
5.Asking for recitation of acquired knowledge	Providing opportunities for scientific discussion and debate among students
6.Testing students for factual information at the end of the unit or chapter	Continuously assessing student understanding (and involving students in the process)
7.Maintaining responsibility and authority	Sharing responsibility for learning with students
8.Supporting competition	Supporting a classroom community with cooperation, shared responsibility, and respect
9. Working alone	Working with other teachers to enhance the science program

(NRC, 1996, p. 52)

Changes Needed in the Continuing Professional Development of Science Teachers

There was little or no debate about the Professional Development Standards for the continued education of teachers. These standards were not even involved in the four year debate nor the attempts to reach consensus concerning the validity of the fourteen Less/More emphasis conditions. In fact, they were conceived after the initial draft was presented to the National Research Council leadership. Discussion at the end of the lengthy process ended in agreement that "teaching" should not stand alone and needed the reinforcement of continuous learning and a research base for teaching throughout the lifetime of every teacher.

The fourteen changes needed and the contrasts between the "Less Emphasis" features and the "More Emphasis" features follow:

Less Emphasis On	***More Emphasis On***
1.Transmission of teaching knowledge and skills by lectures	Inquiry into teaching and learning
2.Learning science by lecture and reading	Learning science through investigation and inquiry
3.Separation of science and teaching knowledge	Integration of science and teaching knowledge
4.Separation of theory and practice	Integration of theory and practice in school settings
5.Individual learning	Collegial and collaborative learning
6.Fragmented, one-shot sessions	Long-term coherent plans
7.Courses and workshops	A variety of continuing professional development activities
8.Reliance on external expertise	Mix of internal and external expertise
9.Staff developers as educators	Staff developers as facilitators, consultants, and planners
10.Teacher as technician	Teacher as intellectual, reflective practitioner
11. Teacher as consumer of knowledge about teaching	Teacher as producer of knowledge about teaching
12.Teacher as follower	Teacher as leader
13.Teacher as an individual based in a classroom	Teacher as a member of a collegial professional community
14. Teacher as target of change	Teacher as source and facilitator of change (NRC, 1996, p. 72)

Changes Needed in Assessment Practices

Assessment too often is associated with testing; it is considered a way of indicating student success with the teaching provided by teachers. Although it was not considered by the assessment "experts" involved with the Standards, the Wiggins and McTighe book (Understanding by Design, 1998) provides a great deal of help in putting assessment in a better perspective. These authors advanced "Backward Design" as a new and important effort. It basically suggests initially establishing what would/could/should be used as evidence for meeting a particular goal. Such consideration should be accomplished before teaching and before planning the curriculum. All of this illustrates that assessment is basic to science itself; it is the collecting of evidence for meeting specified goals and the analysis of the ideas proposed and learned. It is not something someone else does for grading proposes. The NSES summarize the visions for reform in the assessment arena with but seven "Less Emphasis" conditions (i.e., what is commonly done) with seven contrasting "More Emphasis" conditions. These include:

Less Emphasis On	*More Emphasis On*
1.Assessing what is easily measured	Assessing what is most highly valued
2.Assessing discrete knowledge	Assessing rich, well-structured knowledge
3.Assessing scientific knowledge	Assessing scientific understanding and reasoning
4.ssessing to learn what student do not know	Assessing to learn what student do understand
5.Assessing only achievement	Assessing achievement and opportunities to learn
6.End of term assessments by teachers	Students engaged in ongoing assessments of their work and that of others
7.Development of external assessments by measurement experts alone	Teachers involved in the development of external assessments

(NRC, 1996, p. 100)

Need Changes in Defining Content for PreK-12 Science

Certainly the issue of "Content" received the most scrutiny and caused more debate than any other aspect of the NSES effort in the U.S. Everyone had ideas mostly for adding specific "important" content. This was true even with the general view that the curriculum at every level had too much material to cover successfully. Most were willing to concede that the U.S. science curriculum was "a mile wide but only an inch deep". In the end there were eight facets listed to define content for school science. These eight are: 1) unifying science concepts and processes; 2) science as inquiry; 3) physical science; 4) life science; 5) earth/space science; 6) science and technology; 7) science in personal and social perspectives; and 8) history and nature of science. No attempt was made to indicate the relative importance of the eight and/or how to approach the task. To be sure the easiest to grasp were the primary areas where traditionally content is organized – around the basic concepts categorized as life, physical and earth/space science.

Certainly the disciplines of most traditional programs are developed around themes and specific concepts. When considered discipline bound science, only one change in content was the combination of physics and chemistry into physical science. But, this has not changed high school and/or college programs. The first in the list (unification of concepts and processes) was included first because of its perceived importance – but, understandingly, it is still often ignored and not understood. It is too easy to view science as basic concepts in the discipline format found in colleges and high schools. Some would like life, physical, and earth/space to be combined into "major conceptual threads" or one facet of content. Inquiry was considered important and is offered as the primary focus in the seventeen contrasts listed in the general content category as well as contrasts specifically listed for inquiry per se. Inquiry is sometimes labelled as the process skills used by scientists. For some, inquiry is a synonym for science itself. The seventeen contrasts related to content are:

Less Emphasis On	*More Emphasis On*
1.Knowing scientific facts and information	Understanding scientific concepts and developing abilities of inquiry
2.Studying subject matter disciplines (physical, life, earth sciences) for their own sake	Learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science
3.Separating science knowledge and science process	Integrating all aspects of science content
4.Covering many science topics	Studying a few fundamental science concepts
5.Implementing inquiry as a set of instructional processes	Implementing inquiry as strategies, abilities, and ideas to be learned
6.Activities that demonstrate and verify science content	Activities that investigate and analyze science questions
7.Investigations confined to one class period	Investigations over extended periods of time
8.Process skills out of context	Process skills in context
9.Emphasis on individual process skills such as	Using multiple process skills – manipulation,

observation or inference	cognitive, procedural
10. Getting an answer	Using evidence and strategies for developing or revising an explanation
11.Science as exploration and experimentation	Science as argument and explanation
12.Providing answers to questions	Communicating science explanations
13.Individuals and groups of students analyzing and synthesizing data without defending a conclusions	Groups of students often analyzing and synthesizing data after defending conclusions
14.Doing few investigations in order to leave time to cover large amounts of content	Doing more investigations in order to develop understanding, ability, values of inquiry, and knowledge of science content
15.Concluding inquiries with the result of the experiment	Applying the results of experiments to scientific arguments and explanations
16.Management of materials and equipment	Management of ideas and information
17.Private communication of student ideas and conclusions to teacher	Public communication of student ideas and work to classmates
	(NRC, 1996, p. 113)

Changes Needed in PreK-12 Science "Programs"

The NSES Development team decided early that some focus on the total school programs was needed. Few objected to the changes needed in formulating and maintaining exemplary science programs for schools. Little debate ensued. Everyone tended to accept the fact that there are good features to programs – but there is seldom anyone assuring the whole program is working and in agreement with good teaching, learning, and assessments for all facets characterizing the school program.

The NSES envision needed features for programs to support current reforms of school science. The listing certainly includes changes that few would argue with while also encouraging more collaboration, more group efforts, and efforts to make teachers more professional.

The specific eleven contrasts indicate what generally is the situation (i.e., the Less Emphasis conditions) and what is envisioned as ideal in terms of school science programs (i.e., the More Emphasis conditions). These contrasts are:

Less Emphasis On	**More Emphasis On**
1.Developing science programs at different grade levels independently of one another	Coordinating the development of the K-12 science program across grade levels
2.Using assessments unrelated to curriculum and teaching	Aligning curriculum, teaching, and assessment
3.Maintaining current resource allocations for books	Allocating resources necessary for hands-on inquiry teaching aligned with the *Standards*
4.Textbook- and lecture-driven curriculum	Curriculum that supports the Standards, and includes a variety of components, such as laboratories emphasizing inquiry and field trips
5.Broad coverage of unconnected factual information	Curriculum that includes natural phenomena and science-related social issues that students encounter in everyday life
6.Treating science as a subject isolated from other school subjects	Connecting science to other school subjects, such as mathematics and social studies
7.Science learning opportunities that favor one group of students	Providing challenging opportunities for all students to learn science
8.Limiting hiring decisions to the administration	Involving successful teachers of science in the hiring process
9.Maintaining the isolation of teachers	Treating teachers as professionals whose work requires opportunities for continual learning and networking
10.Supporting competition	Promoting collegiality among teachers as a team to improve the school
11.Teachers as followers	Teachers as decision makers (NRC, 1996, p. 224)

Changes Needed in National, State, and Local Systems

The NSES leaders were aware that good science and good science programs are affected by federal, state, and local agencies, policies, and funding. Therefore, they included a set of contrasts between Less and More Emphasis situations for each of these levels. Again, teachers, administrators, school boards, and others too often feel that they have little control over such conditions. In a sense pointing out problems and needs seemed an important consideration in developing standards. The inclusion of visions for changes in political systems suggested that officials – perhaps many leaders with no knowledge nor interest in science - have major influence over the kind of programs, teaching, and assessments that exist in schools and science classrooms.

The contrasts between Less and More conditions with respect to the 20 conditions from the Federal, State, and local levels follow:

Federal System

Less Emphasis On	**More Emphasis On**
1.Financial support for developing new curriculum materials not aligned with the Standards	Financial support for developing new curriculum materials aligned with the Standards
2.Support by federal agencies for professional development activities that affect only a few teachers	Support for professional development activities that are aligned with the Standards and promote system-wide changes
3.Agencies working independently on various components of science education	Coordination among agencies responsible for science education
4.Support for activities and programs that are unrelated to Standards-based reform	Support for activities and programs that successfully implement the Standards at state and district levels
5.Federal efforts that are independent of state and local levels	Coordination of reform efforts at federal, state, and local levels
6.Short-term projects	Long-term commitment of resources to improving science education

State System

Less Emphasis On	**More Emphasis On**
1.Independent initiatives to reform components of science education	Partnerships and coordination of reform efforts
2.Funds for workshops and programs having little connection to the Standards	Funds to improve curriculum and instruction based on the Standards
3.Frameworks, textbooks, and materials based on activities only marginally related to the Standards	Frameworks, textbooks, and materials adoption criteria aligned with national and state standards
4.Assessments aligned with the traditional content of science	Assessments aligned with the Standards and the expanded education view of science content
5.Current approaches to teacher education	University/college reform of teacher education to include science-specific pedagogy aligned with the Standards
6.Teacher certification based on formal, historically based requirements	Teacher certification that is based on understanding and abilities in science and science teaching

District System

Less Emphasis On	**More Emphasis On**
1.Technical, short-term, in-service workshops	Ongoing professional development to support teachers
2.Policies unrelated to Standards-based reform	Policies designed to support changes called for in the Standards
3.Purchase of textbooks based on traditional topics	Purchase or adoption of curriculum aligned with the Standards and on a conceptual approach to science teaching, including support for hands-on science materials
4.Standardized tests and assessments	Assessments aligned with the Standards

unrelated to Standards-based program and practices	
5.Administration determining what will be involved in improving science education	Teacher leadership in improvement of science education
6.Authority at upper levels of educational system	Authority for decisions at level of implementation
7.School board ignorance of science education program	School board support of improvements aligned with the Standards
8.Local union contracts that ignore changes in curriculum, instruction, and assessment	Local union contracts that support improvements indicated by the Standards

(NRC, 1996, p. 239)

Argument is offered that all too few science education leaders, consultants, and NSTA members, officers, and staff are really aware of the More Emphasis visions; nor are they using them in their day-to-day efforts. Too few condemn the textbook companies, kit developers, school personnel for defining the needed changes in the seven areas, and in specific ways indicated by the 82 More Emphasis summary statements quoted directly from the NSES. The four years of debate and $7 million expended deserve more attention and use. More should challenge the claims for the "standards-based" materials and practices in terms of their being considered and actually focused on the NSES visions!

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