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Achieving The Staff Development Model Advocated In the National Standards

An argument is made that more actions are needed by more professionals in more schools if the visions of the National Science Education Standards are going to succeed in accomplishing the illusive reforms for which the science education community has so often strived.

The early drafts of the National Science Education Standards (NSES) did not include any mention of staff development; it was not considered as part of the needed visions for changing school science. There was never any intention that the Standards would indicate minimum competencies that would be required of all. Instead, the focus was on visions of how teaching, assessment, and content should be changed. It was a matter of choice that elaboration of content would follow considerations of changes in teaching and assessment strategies. First of all, there was fear that everyone would look first (and perhaps only) at content—and ignore all else. Too often reform and improvement is defined as new organization of materials for teachers to use. Even though suggestions for content inclusion were not placed first in the NSES, they still resulted in the most discussion, concern, and debate among those responsible for preparing the Standards. It is almost as if what one teaches, and when, and for how long it is taught, are all that is really important.

The final draft of the Standards appeared in 1996 after four years of debate and an expenditure of nearly $7 million. Several early drafts were circulated widely with invitations to comment, suggest, debate, and assist with attaining a consensus document. A director of consensus provided leadership and assistance as final drafts were assembled. Early on, programs and systems were added as follow-ups of teaching, assessment, and content. But, as indicated, professional development standards were offered as a sixth area and placed after teaching and before assessment in the final draft of the Standards. It was when the final draft was offered to the leadership in the National Academy of Sciences that a section on Staff Development was added 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 of existing teachers, and any improved ways of preparing teachers were to be realized. In many respects these standards for encouraging teacher development and growth were vital to implementing the Standards; and yet they were non-controversial while being viewed by many as the most important part of the Standards for achieving the visions which the other parts suggested.

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The NSES and Professional Development

There are fourteen features of Professional Development (PD) included in the NSES; all are considered vital if the Standards are to result in progress for assuring continued growth and development of all in-service teachers. They also provide suggestions for the features needed for programs designed to prepare new teachers. Figure 1 provides a listing of conditions suggested in the National Standards as needed if such programs are to succeed to the fullest.

Figure 1. The National Science Education Standards envision change throughout the system.
The professional development standards encompass the following changes in emphases:

Less Emphasis On	***More Emphasis On***
• Transmission of teaching knowledge and skills by lectures	• Inquiry into teaching and learning
• Learning science by lecture and reading	• Learning science through investigation and inquiry
• Separation of science and teaching knowledge	• Integration of science and teaching knowledge
• Separation of theory and practice	• Integration of theory and practice in school settings
• Individual learning	• Collegial and collaborative learning
• Fragmented, one-shot sessions	• Long-term coherent plans
• Courses and workshops	• A variety of professional development activities
• Reliance on external enterprise	• Mix of internal and external expertise
• Staff developers as educators	• Staff developers as facilitators, consultants, and planners
• Teacher as technician	• Teacher as intellectual, reflective practitioner
• Teacher as consumer of knowledge about teaching	• Teacher as producer of knowledge about teaching
• Teacher as follower	• Teacher as leader
• Teacher as an individual based in a classroom	• Teacher as member of a collegial professional community
• Teacher as target of change	• Teacher as source and facilitator of change

(NRC, 1996, p 72)

The first change suggested for improving PD programs is *less emphasis* on transmitting teaching knowledge and skills by lecture (a feature of most staff development initiatives of school funded programs and for typical college/university teaching). Instead the Standards call for the focus to be one of inquiry into teaching and learning. This, of course, emphasizes the use of questions that leads to learning and the identification of possible answers that could be tested as a means of collecting evidence that the explanations and ideas are valid.

The Standards continue to de-emphasize lecture and reading as models for instruction in favor of learning through investigation and inquiry. Again, they de-emphasize the transmission of information and skills directly by teachers to students. This departs 180° from the way learning is portrayed and modeled in traditional collegiate settings.

Another feature of the PD Standards consists of dropping the idea that science and teaching knowledge can or should be separated in PD efforts, instead ensuring that they are approached in an integrated fashion. Similarly, the Standards suggest less emphasis on separating theory from practice, and *more emphasis* on their integration, especially when in school settings.

One could argue that "real" science is seldom encountered or experienced in most science classrooms.

The Standards emphasize that individual learning needs to change to more collegial and collaborative learning. The Standards identify fragmented, one-shot sessions as problems to be replaced with long-term, coherent plans (probably taking place over several years). Project 2061, the major reform suggestions advanced by the American Association for the Advancement of Science (AAAS), suggests such a plan should coincide with the life span of a human being, perhaps 75 years (Rutherford and Ahlgren, 1990).

The Standards suggest that current workshops should not describe and outline visionary PD models; instead, a great variety of activities and approaches should be used. And, these should be models for the enrollees to experience directly and to prompt discussion and debate among all concerned—something to be used in K-12 science classrooms.

The Standards also de-emphasize the reliance on external expertise; they suggest the importance of the involvement of local teachers and consultants as well as outside persons with specific expertise and experience. The Standards suggest that there be *less emphasis* on staff development seen as efforts on the part of "experts" and more of an emphasis on them serving as facilitators, consultants, planners, and questioners. Teachers are portrayed less as technicians (factory workers) and more as intellectual, reflective practitioners (professionals). Teachers are viewed (by the Standards) less as *consumers* and more as *providers* of knowledge concerning teaching. Teachers are portrayed less as *followers* and more as *leaders*. They are seen less as persons housed in a classroom and more as a member of a professional community. The teacher is not seen as "the target" for change, but as a source and facilitator of change.

How Teachers Must Change

Professional Development is about ensuring that teachers continue to grow and improve. It 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 learning does result—and that it is learning with understanding and potential use after students leave the school classrooms and laboratories—and not merely an indication of attention, remembering, repeating, reciting, duplicating words, definitions, skills, activities, and verbiage.

Again, the NSES clearly state nine ways teaching should change to result in more and better student learning and to move toward meeting the stated goals. These changes are summarized in the NSES as contrasts between *less emphasis* conditions (which are commonly used strategies by most teachers) and the *more emphasis* conditions which are needed for science teachers to be successful in producing students who have learned with understanding. These contrasts are indicated in Figure 2.

The teaching standards are first in the 1996 publication because of their importance in realizing the goals and because they were the least controversial of all the visions contained in the NSES. These changes in teaching are the targets for improving in-service teaching and the needed skills for science teacher preparation.

The nine *more emphasis* conditions provide another way to measure the success of PD efforts. Do we get teachers who exhibit the *more emphasis* conditions? How much improvement has been found? What else should be emphasized and modeled as part of an exemplary PD program? A new monograph prepared by the leadership of the National Science Teacher Association (NSTA) will be published in 2005 and featured at the March 31 Conference in Dallas. It includes sixteen exemplary programs that illustrate where we are with respect to successful implementations of the Professional Development Standards elaborated in the NSES.

Education has become *training*; i.e., getting students to accept and be able to recall explanations others have offered.

Figure 2. The Ways Teaching Must Change if the NSES Visions for Reform are to Occur

Less Emphasis On

- Treating all students alike and responding to the group as a whole
- Rigidly following the curriculum
- Focusing on student acquisition of information
- Presenting scientific knowledge through lecture, text, and demonstration
- Asking for recitation of acquired knowledge
- Testing students for factual information at the end of the unit or chapter
- Maintaining responsibility and authority
- Supporting competition
- Working alone

More Emphasis On

- 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 inquiry
- Providing opportunities for scientific discussion and debate among students
- Continuously assessing student understanding
- Sharing responsibility for learning with students
- Supporting a classroom community with cooperation, shared responsibility, and respect
- Working with other teachers, local experts and school and community leaders to enhance the science program

(NRC, 1996, p 52)

A New NSTA Monograph High-Lighting P.D. Models

The National Science Education Standards (NSES) clearly articulate four goals (justifications) for requiring science in K-12 schools. These four goals illustrate the major focus for producing students who can:

1) experience the richness and excitement of knowing about and understanding the natural world;
2) use appropriate scientific processes and principles 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 and understanding, and skills of the scientifically literate person in their careers

(NRC, 1996, p.13)

For many the first goal is the most important since it ensures the every student will have a firsthand personal experience with the whole scientific enterprise. This means exploring nature with a natural curiosity which all humans enjoy. It means asking questions, identifying the unknown, proceeding to knowing—even if it is a personally constructed answer or explanation (but wrong in terms of current science academy notions) of the original question arising from personal curiosity. Again, all humans do this in different ways. Artists see beauty, poets express feelings, dancers dance. In science the exploration of natural phenomena must include evidence produced by some manipulation of nature, and others must accept the evidence before science is done.

What Is Basic Science?

Science educators tend to define science as the information found in textbooks for K-12 and college courses or the content outlined in state frameworks and standards. Such definitions omit most of what George Gaylord Simpson (1963) described as the essence of science; Simpson's five *activities* which define science are:

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, 1963, p. 3)

The elements of science identified by Simpson are rarely studied in schools. For example, 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., 1994). In fact typical school science treats science concepts as givens—something to be transmitted to students via textbooks and teacher lectures often following closely State Standards which have all too often negated the National Standards.

NSELA members need to become the conscience for society by insisting on a more precise definition of science and what this means for school programs and, more importantly, for teaching science in schools.

One could argue that "real" science is seldom encountered or experienced in most science classrooms. The typical focus is almost wholly on what current scientists accept as explanations (Harms & Yager, 1981; Weiss et al., 1994). Competent science students only need to remember what teachers or textbooks say. Most laboratories are but verification activities of what teachers and/or textbooks have indicated as truths about the natural world. There is seldom time for students to design experiments that could improve human existence.

Science education should be about drawing people out in terms of engaging their minds. Instead, most science programs focus on directing students to what they should learn—i.e., the explanations of objects and events that scientists have accepted as truths or explanations of the natural world and/or technological achievements (e.g., automobiles, airplanes, air conditioners) (AAAS, 1990a).

Education has become *training*; i.e., getting students to accept and be able to recall explanations others have offered. This is often done under the pretext that specific concepts and process skills are necessary prerequisites for understanding, even though it is now apparent that such approaches are useless and that understanding is rarely accomplished until students see the importance of those concepts and skills, and the need for them (Resnick, 1987; NRC, 1999; Greeno, 1992).

Realizing the NSES Visions

What we now know about effective Professional Development for science teachers should provide the framework for all the efforts of members of the National Science Education Leadership Association (NSELA). NSELA members are the leaders who will determine what goes on in K-12 schools with respect to science programs. Leaders should not blindly follow what others mandate or direct. Too often such attempts at reform are alien to what good leadership suggests and certainly do what science itself entails.

NSELA members need to become the conscience for society by insisting on a more precise definition of science and what this means for school programs and, more importantly, for teaching science in schools. Too often teachers as well as the general public are too willing to ignore the essence of science and to relegate its teaching to the topics too often characterizing curriculum frameworks, textbook chapters, the "agreed upon" concepts too often packaged in discrete disciplines.

Paul DeHart Hurd often reminded us that the traditional disciplines are no longer useful and only exist as designations for college departments and secondary school courses. All current research now is blurred in terms of discipline structure. And, instead of science leading to technology (often called applied science), now scientific research is completely dependent upon new technologies. The future of science education is rooted in its alignment with technology (and mathematics research and structure). It will take time for all the reforms to succeed and to be successful. But, NSELA members must assume the needed leadership if it is to proceed in meaningful ways in these tumultuous times.

School science is rarely seen as an experience that enriches and excites students about their knowledge and understanding of the objects and events found in the natural world.

The first and overarching goal for science education for the decade following the 1996 publication of the NSES is to provide a direction for our field and is listed first in the NSES narrative (NRC, p. 13). All science educators (and especially NSELA members) must internalize and work diligently toward meeting this important goal and justification of science in K-12 schools. It should be the goal that unifies us all. But it will be the most difficult to achieve! School science is rarely seen as an experience that enriches and excites students about their knowledge and understanding of the objects and events found in the natural world.

Reconsidering Scientific Literacy

Paul Brandwein once said that science literacy would begin to be realized if every student had even one full experience with science as it is defined by Simpson (1963). Brandwein contended that most high school graduates complete their schooling without even one experience with real science. Many within NSTA have argued that we should aim for more than one science experience in thirteen years—instead, a better goal would be at least one for each year of the thirteen-year continuum of a general education for all. Even then, most teachers would argue that thirteen such experiences are but "a drop in the bucket." In the early 80s, a quarter of a century ago, NSTA called for science to be offered "every day for every year that a student is enrolled in school." Earlier NSTA had proclaimed that producing scientifically literate graduates was the primary aim of science education. Many worried as to what this meant; some felt that it was a call to focus more on learning "about" science. Some looked at the failure that a focus on curriculum changes caused and the fact that few real changes emerged that improved student learning. It should be remembered that change is dependent on leadership and change in education is indeed slow. Effective leadership can make it happen sooner!

The other three goals from the NSES (in addition to ensuring that all students experience the essence of the whole sequence that characterizes science) focus upon experiences in school science which will affect the daily lives of students that can help them make better scientific and societal decisions and lead them to increase economic productivity. These are seen as a way to achieve a fuller scientific literacy. These three NSES goals are rarely approached, realized, or assessed in typical classrooms by typical teachers. Information that would help in realizing these goals are 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 can be achieved. In *Backward Design,* Wiggins & McTighe, (1998) provide ideas about what needs to be done—what evidence we need to be sure we have met Goal 2 (i.e., using appropriate scientific methods and principles for making personal decisions) must be practiced in the classroom and beyond. Efforts are needed to collect evidence to indicate that each goal is met. 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 in daily living.

Taking Actions as a Result of School Science

Another focus for school science must be on involving students in public discourse and debate in school, and in the outside community, beyond life for any given year. Perhaps the best evidence that this goal had been met is in the involvement of students in their school and community affairs. Where do they actually use what is in the curriculum and what teachers teach? A whole new way of viewing content,

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instruction, and assessment is needed if this goal is to be realized as one of those proposed in the NSES.

The fourth goal may be the most difficult to achieve and to assess. In some ways it is even further from daily life and the immediate community. It focuses on economic productivity, possible career choices, and the use of the typical concepts and processes which often provide only a two-dimensional view of science. This could be construed as taking long range actions arising from school science study.

Where We Are with Implementing NSES Visions

We have had eight years to reach the visions advanced for Science Education for the decade following the publication of the NSES. The NSTA series dealing with exemplary programs will be available shortly to highlight the most successful schools and teachers in meeting these visions. Some are already planning to develop new Standards—perhaps to chart new pathways. Some worry, however, that these are so few instances where substantial progress has been made. Nonetheless, it is generally agreed that ten years is a targeted time to take assessment of progress and to find new ways to reach these goals. More actions are needed by more professionals in more schools if the NSES visions are going to succeed with accomplishing the illusive reforms for which we have so often strived.

Features of a Model PD Program

One effort in the staff development arena which continues to grow and change based on experience is the Iowa Chautauqua Model (ICM). It was initiated in 1983 as one of seventeen projects funded by NSF and coordinated by NSTA. It was initiated after NSF decided not to support further the long time AAAS project to provide summer workshops and follow-up meetings for college faculty (mainly faculty from four-year colleges and community colleges). It was designed to use noted researchers and making them available to enthuse and involve science faculty who no longer have engaged in major research efforts. This annual sequence seemed ideal as a way to engage K-12 teachers in similar efforts over the course of a full year in accomplishing needed reforms. The Iowa Chautauqua was initially funded for three years as a program for middle school teachers and attracted further support from industry and a new National Science Foundation (NSF) grant after the NSTA effort (3 years) terminated. Later Iowa Chautauqua was the vehicle for involving teachers and schools in the NSTA Scope, Sequence, and Coordination (SS&C) project which enjoyed major funding and support for a seven year period (1990-97).

Iowa Chautauqua and later Iowa SS&C were approved by the Program Effectiveness Panel (PEP) of the U.S. Department of Education, funded by the National Diffusion Network, validated the Northwest Regional Laboratory and the Middle School Research Association as a professional development model which embodies the professional development needs as identified in the HRI (Horizon Research Institute) study of such programs (Weiss, 2002).

Iowa Chautauqua continues work in Iowa (through National Diffusion Network (NDN) work in 12 other states) but over a period of one to three years for K-12 teachers. Basically, the Iowa Chautauqua Program is at least a whole year-long staff development sequence designed to help K-12 science teachers align their curricula, instruction, and assessments with the visions embodied in the National Science Education Standards. The standards establish eight content areas for science education: unifying concepts and processes, science as inquiry, physical science, life science, earth and space science, science and technology, science in personal and societal perspectives, and history and nature of science.

The program prepares teachers to pilot test short teaching units during the fall based on content standards in these areas. After additional collaboration and training (including action research projects), teachers working in teams develop and pilot longer instructional modules adapting curricular materials developed nationally (often with federal support). The eventual goal is the creation of a unified school-wide curriculum and assessment plan.

Figure 3. A View of the Sequence of Activities Describing the Iowa Chautauqua Model

LEADERSHIP CONFERENCE

A Week Long Conference Designed To

1. Prepare staff team for conducting a workshop series which follows for 30 new teachers.
   a) One lead teacher for no more than ten new teachers
   b) Scientists from a variety of disciplines
   c) Scientists from industry
   d) Administrators
   e) Science Supervisors/Coordinators as chair of staff teams
2. Organization and scheduling for each workshop
3. Publicity and reporting
4. Assessment strategies
   a) Six domains
   b) Use of student reports
   c) Teacher journals/notebooks, new research plans for Lead Teachers

THREE WEEK SUMMER WORKSHOP

Teaching and Learning as Outlined in the NSES

1. Includes special activities and field experiences that relate specific content within the disciplines of biology, chemistry, earth science, and physics—all related to the four goals of teaching science in the NSES.
2. Makes connections between science, technology, society within the context of real world issues.
3. Issues such as air quality, water quality, land use/management provide context for concept development.

Figure 3. continues on page 23

Figure 3. continued

ACADEMIC YEAR WORKSHOP SERIES		
Fall Short Course ⇨	Interim Project ⇨	Spring Short Course
Awareness Workshop	Three Month Interim Project	Final Workshop
20 hr. Instructional Block (Thursday p.m. Friday, & Saturday)	**The STS Module**	**20 hr. Instructional Block** (Thursday p.m. Friday & Saturday)
Activities Include: 1. Reviewing problems with traditional views of science and science teaching 2. Outlining essence of the broader definition of science. 3. Defining techniques for developing new modules and assessing their effectiveness 4. Selecting a tentative module topic 5. Practicing with specific data collection assessment tools in each assessment Domain.	Activities Include: 1. Developing instructional plans for minimum of twenty days 2. Administering pretests in six domains 3. Teaching the module utilizing student ideas and prior experiences. 4. Collecting posttest information 5. Communicating with regional staff, Lead Teachers and central Chautauqua staff	Activities Include: 1. Reporting on the teaching and learning experiences 2. Reporting on multiple assessment efforts 3. Interactions concerning new information arising from the action research in the classrooms of all participants 4. Planning for involvement in professional meetings 5. Planning for next-step initiatives

Establishing Successful P.D. Programs

The Chautauqua program prepares teachers to use constructivist instructional strategies in the classroom. This means less emphasis on lecture, demonstration, memor-ization, and rigid adherence to curriculum. It means more emphasis on discussion, teacher collaboration, active inquiry, cooperative learning, continuous assessment of student understanding, and use of student experience and local issues as vehicles for learning.

The Iowa Chautauqua program and its successor, the Iowa Scope, Sequence, and Coordination project, have been evaluated by outside evaluator teams, doctoral candidates, annual assessment reports, and studies in 10 states and 6 international settings. Most of these studies have focused on changes in teacher practice and attitude. Several, however, have examined student achievement in six domains of science learning: concepts, process skills, applications, creativity, world view, and attitude. In one study, for example, 15 lead teachers each taught one science class using the Chautauqua approach and another using a traditional textbook approach. Students (a total of 722) were randomly assigned to treatments and traditional classes. Pre-tests were given to students in September and post-tests in April. The type of test used varied from domain to domain. For example, the concept domain was assessed with multiple choice tests available from textbook publishers, the process domain with 13 skills identified by the American Association for the Advancement of Science, and the application domain by multiple choice items generated by program developers. The results revealed no difference between Chautauqua and control students in the concept domain (traditional science content); in the other five domains, however, Chautauqua students demonstrated significantly more growth than control students.

Other studies have found that female students in classrooms taught by Chautauqua teachers have more positive attitudes towards science than counterparts in traditional science classes. Studies have also demonstrated numerous positive effects on teachers, including better understanding of the nature of science and greater ability in ability to teach it. Figure 3 is an outline of the features of Iowa Chautauqua Model.

A Broader View of Science

It is probably important to remind ourselves that learning is something that the brain is designed to do. Perhaps of even more importance is the fact that real learning is occurring even when it seems that many students do not succeed in school because they do not seem to learn what teachers teach or what is in the curriculum. The assumption is too often that they have not learned at all.

Frank Smith in his book "The Book of Learning and Forgetting" (see Figure 4) distinguishes between what learning is classically and what it has become officially in institutions called schools (Smith, 1998).

Learning about Professional Development is just like learning in school. But the official theory is not the one that the NSELA leaders should follow; it is time to renew use of what Smith calls the classical theory of learning and in so doing revise the official view of learning which exists in most schools. We should be pushing for use of the classical theory in our work with teachers for change and ignore the so-called official theory which is the root of most of our failures for reforms in science education in schools.

Figure 4: Views of Learning (From the book Learning and Forgetting).

The classic view (of how humans learn) indicates that real learning is	*The official theory (which governs schools) results in learning that is*
continual	occasional
effortless	hard work
inconspicuous	obvious
boundless	limited
unpremeditated	intentional
independent of rewards and punishment	dependent on rewards and punishment
based on self-image	based on effort
vicarious	individualistic
never forgotten	easily forgotten
inhibited by testing	assured by testing
a social activity	an intellectual activity
growth	memorization

(Smith, 1998, p. 5)

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