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ABSTRACT

In February, 1996, representatives of departments of education and major teacher education colleges in 39 states, the District of Columbia, the U.S. Virgin Islands, and the U.S. Department of Defense met at the National Academy of Sciences in Washington, D.C. to identify and discuss issues surrounding the preparation and credentialing of science teachers. Central to this symposium were the criteria identified by the National Science Education Standards for effective science teaching and effective professional development for science teachers. This synopsis is intended to encourage reflection by participants and their colleagues at the state level on the issues identified, reactions to those issues from a variety of perspectives, and strategies for addressing those issues as outlined by others. Responses include: (1) "The Need for Scientifically Literate Teachers" (Bruce Alberts); (2) "The Need for Reform in State Policy" (William Randall); (3) "The Need for Reform in Teacher Preparation Programs" (Robert Watson); (4) "Implications of the Standards for Teacher Preparation and Certification" (Pascal Forgione); (4) "Response to Dr. Forgione" (Angelo Collins); (5) "The Standards: A Guide for Systemic Reform" (Rodger Bybee); (6) "The Standards: A Guide for Professional Development" (Susan Loucks-Horsley); (7) "The Montana Systemic Teacher Education Preparation Project" (Robert Briggs and Elizabeth Charron); (8) "The Louisiana Collaborative for Excellence in the Preparation of Teachers" (Kerry Davidson, William Deese, Linda Ramsey, and Carolyn Talton); (9) "The Connecticut Science Education Assessment Program" (Michal Lomask and Raymond Pecheone); (10) "Reflections on Pre-service Education and Teachers' Needs" (William Badders and Celeste Pea); (11) "Response to the Teachers' Comments" (Arthur Wise); (12) "A Science Educator's Perspective on Teacher Education" (Paul Kuerbis); (13) "The Role of Undergraduate Science Courses in Teacher Preparation" (Patricia Simpson); (14) "A Principal's Perspective on the K-12 School's Role in Preparing Teachers" (Mary Ann Chung); (15) "A Perspective on the State's Role: Motivation and Policy" (William Randall); (16) "Concern,

Collaboration, Coordination, and Communication" (Jane Butler Kahle); (17) "Response to Dr. Butler Kahle from the State Perspective" (Terry Janicki); and (18) "Closing Remarks and Challenge for Next Steps" (Virginia Pilato). (ASK)

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Improving Teacher Preparation and Credentialing Consistent with the *National Science Education Standards*

Report of a Symposium

Center for Science, Mathematics, and Engineering Education

NATIONAL RESEARCH COUNCIL

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Background

The *National Science Education Standards* create a vision of classrooms as environments where students learn through both mental and physical activity. The science education envisioned in the *Standards* requires substantive change in how science is taught in K-12 classrooms, and equally substantive change in the professional development of teachers. For this vision to become a reality, teachers themselves must experience good science teaching in their professional development programs. Policies and criteria for licensure of teachers must reflect how science is learned and how science should be taught. Specifically, teacher preparation and credentialing need to be consistent with the *National Science Education Standards.*

On February 4-6, 1996, representatives of departments of education and major teacher education colleges in 39 states, the District of Columbia, the U.S. Virgin Islands, and the U.S. Department of Defense met at the National Academy of Sciences in Washington, D.C., to identify and discuss issues surrounding preparation and credentialing of teachers of science. Central to this symposium were the criteria identified by the *Standards* for effective science teaching and for effective professional development for teachers of science.

Goals established for the symposium were for state teams to

- increase their understanding of the *National Science Education Standards;*
- explore the impact of the *Standards* on teacher preparation programs;
- identify and discuss goals, effective strategies for change, and ongoing challenges related to teacher education and certification within their state; and
- develop plans for statewide implementation of *Standards*-based teacher preparation programs.

The symposium did not produce formal recommendations. Because the *Standards* clearly state that the responsibility for policy rests with the state and local school systems, the agenda was structured to allow state teams to define their needs, to consider strategies for improving their policies and programs in

teacher preparation, and to work on translating the teaching and professional development standards into practice. Break-out groups followed each presentation to encourage in-depth discussion from diverse perspectives. Each day also included time for state teams to meet, exchange experiences from the break-out groups, discuss issues, and incorporate this information into their state action plans. Following the symposium, team leaders reviewed the action plans with their respective departments of education.

The synopsis that follows is intended to encourage reflection by participants and their colleagues at the state level on the issues identified, reactions to those issues from a variety of perspectives, and strategies for addressing those issues as outlined by others. This report also will serve as a self-monitoring tool for states. Which actions were successful? Which actions needed to be reconsidered or revised? Will some of the actions require more time, money, or personnel? Reviewing the action plans from all state teams can also serve as a tool for others who have yet to begin addressing the need to examine and reform policy and practice in teacher education and certification.

Synopsis of Symposium Presentations

Opening Remarks at the symposium focused participants on the vision of science for all, the reality of state and federal policies and programs, and the need for collaboration to bring about change in those policies, programs, and practice.

The Need for Scientifically Literate Teachers

Bruce Alberts, President, National Academy of Sciences

Science should be a core subject—not an add-on—in every year of school, starting in kindergarten. Science must be for all students, not just to produce scientists but to produce citizens who can find jobs and can be effective in their personal lives. Science cannot be taught as words to be memorized from textbooks and then tested on multiple choice exams. Science must be taught as inquiry-based learning, with hands-on, problem-solving exercises.

We have to rethink how we prepare teachers. Science and mathematics teachers need pedagogy that is subject matter specific, not general. In many cases, our existing programs teach things that teachers do not need and do not teach things that they do need.

The Need for Reform in State Policy

William Randall, Commissioner, Colorado Department of Education; President, Council of Chief State School Officers

Keep in mind that in the United States the state is the focus for education, not the federal government. It is very important that anything we talk about doing, we talk about in the framework of how the states are organized and how they are trying to link the science education in the K-12 system with both undergraduate and graduate programs so that we can have science teacher quality in all our classrooms. It is time to start breaking down the old structures and artificial barriers that now exist in the states, the universities, and the schools.

The Need for Reform in Teacher Preparation Programs

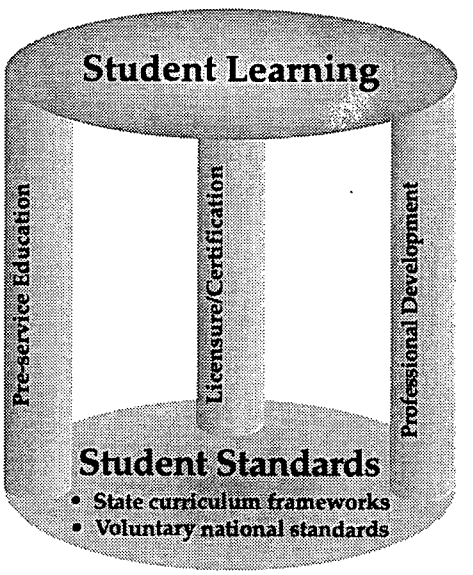
Robert Watson, Director, Division of Undergraduate Education, National Science Foundation (NSF)

Current efforts at NSF place emphasis on getting scientists, science departments, and science, mathematics, and engineering schools to take on a more appropriate role in the preparation of future teachers and to form better partnerships with their colleagues in the colleges of education. I am convinced that if science departments in colleges and universities were more hospitable to students who would become teachers, then not only would those students be better prepared to go into teaching but a much stronger cadre of students would be attracted to teaching.

Keynote Address: Implications of the Standards for Teacher Preparation and Certification

Pascal Forgione, Delaware Superintendent of Public Instruction

This is a unique, unprecedented opportunity. The *National Science Education Standards* provide mutual direction on a large scale: there are clear expectations and real-world standards set within a common vision of excellence and equity for all. All students means all, and that is a distinctive feature of this reform. We are talking about this vision for all, moving the whole distribution of students to a higher and more appropriate level of performance. That vision has to come from the top.



To accomplish reform in science education and for students to achieve higher levels of learning, teachers need support for change in three areas: pre-service education, certification and licensure policies, and professional development programs.

The development of high-quality and rigorous content standards is the foundation for student achievement, but a foundation is not sufficient to ensure high-quality opportunities for all students to develop an understanding of science. Although we may have the vision, unless that vision is founded in the expectation of what students should know and do, unless that vision is clearly articulated, unless that vision is widely held, and unless that vision becomes a reality, all children will not have the opportunities needed to understand the beauty and complexity of science.

So, what does it really mean to teach to the *Standards*? We need to identify what teachers must know and be able to do in order to deliver high-quality learning opportunities for students. Content and pedagogical content knowledge must become part of the pre-service experience. Higher education must build upon its tremendous

innovation, knowledge, and creativity to create undergraduate programs that are consistent with the *Standards*. The programs must prepare teachers at all grade levels to teach to the *Standards* for all children. Graduate and continuing education programs for our current teaching force must be based on the content and methods in the *Standards* for teaching all children at all grades.

Certification policies must be aligned with the *Standards* and requirements for certification must be aligned with the content standards for students and reflect the understandings that teachers must have in science and in the teaching of science. Continuing professional development certainly is necessary to renew your license to teach. But we need to expect more from the process, and we need to develop an articulated scope that has an impact on student learning. We need a renewal process that reflects on teaching, not just a count of credits.

The National Science Education Standards *are designed to guide our nation toward a scientifically literate society. The first morning of the symposium was devoted to understanding the* Standards, *the criteria for teaching and learning science presented in the* Standards, *and the implications of the* Standards *for change in state policies and for institutions of higher education that prepare teachers.*

Response to Dr. Forgione

Angelo Collins, Professor of Education, Vanderbilt University; Director of Development, National Science Education Standards Project

Curriculum, assessment, and teaching are the three legs of reform in science education. The focus today is on the most important: teaching. How we select and promote people into the teaching profession is an extremely important task. It is time for teachers to be recognized as professionals. Professionals have both theoretical and practical knowledge of their profession. They have control of that profession and are service oriented. Professionals have professional working conditions. Being recognized as a professional grants status and has rewards.

The *National Science Education Standards* call for prospective teachers to learn science in the way they are going to teach it: as inquiry and for full understanding. They are to learn to teach science in the places where science teaching happens. They are to be members of life-long communities of learners, and they are to experience coherent and integrated professional development programs. The challenge is to move from national standards that represent a vision to state programs at our colleges and universities in order to work together for the future of education.

The Standards: A Guide for Systemic Reform

Rodger Bybee, Executive Director, Center for Science, Mathematics, and Engineering Education; Chair, Working Group on Science Content Standards

The *National Science Education Standards* present a thorough, complete, and adequate definition of scientific literacy and give a thorough, complete, and appropriate presentation of science content. But reform is not about standards.

Reform is about improving teaching and student learning. We cannot stop now and say, "Okay, we have standards. That is it, that completes the reform." We have to keep going. The reform of science education is a long-term project.

Keep your eye on the teachers. If this reform is going to work, we have to keep our eyes on the teachers. That is where the real reform has to happen. It is not curriculum materials—it is the teachers. The reform is not out there somewhere. It is not going to happen to us some other day in some other way. It is not just sitting out there. The reform is us, and it is what we are doing. We are the reform, and I think we have the opportunity for significant improvement with the *Standards*.

The Standards: A Guide for Professional Development

Susan Loucks-Horsley, Senior Researcher, National Center for Improving Science Education; Senior Research Associate, WestEd; Member, Working Group on Science Teaching Standards

Good professional development mirrors good teaching: learning by doing, learning through inquiry, learning through collaboration, learning over time, and developing personal meaning. Those are the ways to help teachers learn and the ways that we need to help ourselves learn. This reform is all about learning—all people learning, not some people learning.

We need to stop thinking of teachers as targets but rather as co-learners, as sources of important knowledge, and as facilitators of their own growth and the growth of others. We need to move the concept of professional development from technical training to career-long support for professional growth. The professional development standards help point the way.

The National Science Education Standards *were developed by committees and working groups of highly qualified and respected scientists and science educators. Participants at the symposium heard from members of the* Standards *working groups, then had the opportunity to engage in small group discussions to clarify understandings and interpretation of the vision and intent of the document.*

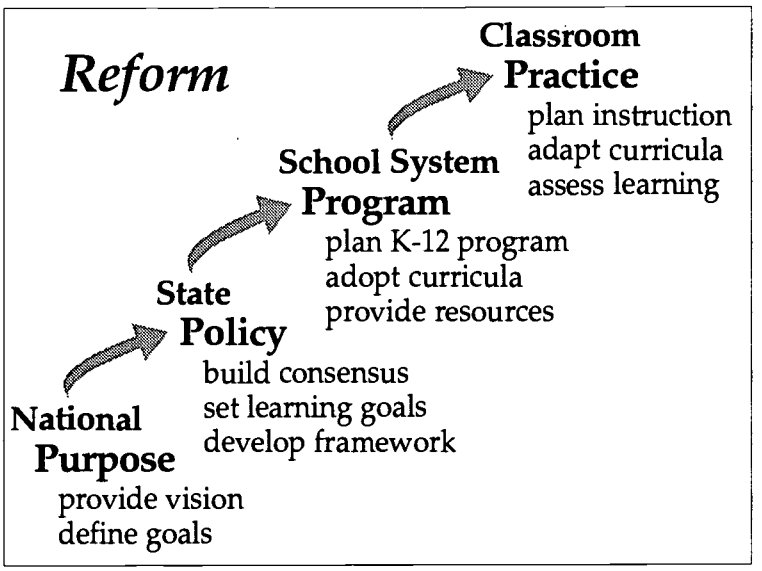
Professional Development Standard A: Learning Science Content

Teachers need to understand and to inquire into the nature of science and what science has to offer. There are some "how's" and "what's" all teachers should know. The first is inquiry: the nature of inquiry, the processes of inquiry, what inquiry is about, what inquiry is, and how to do it. Teachers should have the abilities needed to conduct an inquiry.

Teachers *at all levels* need to know the fundamentals of the major disciplines of science—the big ideas. They need to understand the connections across the disciplines and the connections with math, technology, and other subjects. They need to understand and to be able to apply scientific understandings to their own lives and to societal issues.

Teachers will teach science the way they learned science. If they continue to have the same traditional kinds of courses in their undergraduate science prepa-

ration, that is the way they will teach. The "how's" for teaching science according to the *Standards* are: guiding active investigation, encouraging reflection, and supporting collaborative work.



The policies outlined in the *Standards* have to be translated into programs. The policies of the *Standards* must be translated into credentialing and licensure requirements in each state. Other groups will translate them into curriculum materials or into undergraduate science programs. The very big, critical step is to move toward a change in classroom practice.

Professional Development Standard B: Learning to Teach Science Pedagogical content knowledge is what sets apart good teachers from scientists. It is what makes the professional teacher an expert in his or her profession. It is what teachers know who are skilled at working with students on the concepts those students can learn, identifying when the students can learn the concepts, and making the concepts real to the students. Pedagogical content knowledge is the "what" of the second professional development standard.

There are six science teaching standards that define what teachers need to learn in order to teach. Teachers need to learn to plan and to design learning environments. They need to learn to facilitate learning and to help students develop understanding. They need to learn to assess and to support communities of learners. In short, they need to learn how to design and implement the school science program.

We talk about integrating the understanding of science with the understanding of pedagogy. Teachers need to learn this through experiences that model good teaching—experiences that allow teachers to inquire into learning and teaching in the same way they inquire into science: using inquiry, reflection, research, and so on.

Professional Development Standard C: Learning for a Lifetime We thought it was extremely important to include a standard that addressed the ability, the tools, and the inclination to continue to learn. As a result, the "learning-to-learn" standard was developed. There are a number of different facets to this standard, including being able to reflect on one's own practice, to take feedback, to give feedback, to take advantage of a mentor, to be a mentor, and then to actually do

research on one's own classroom teaching. The standard also includes opportunities for teachers to deepen their content knowledge over time—to know where to go and how to stay up to date in their disciplines.

Professional Development Standard D: Coherent, Quality Programs This standard is about organization, the structure of programs, and being more programmatic about professional development at all levels. This is really what you are here to talk about, for we need coherent and integrated programs at all levels. Some of the coherence-building pieces are goals and visions that are shared among all the different parts of the science education community.

We heard earlier about how important it is for all parties involved in the preparation of teachers to work together, coordinating the components and building in those same elements of continuous assessment, reflection, improvement, and collaboration that you have seen before. We need less separation of science and teaching; pedagogical content knowledge is the glue. We need less separation of theory and practice; being on site in the context of the learning situation is the glue. We need less individual learning and more collegial and collaborative learning. We need less fragmentation and more coherence.

We need the courage to go off the beaten path, and I wish you success with the programs you will be putting together.

The Montana Systemic Teacher Education Preparation Project (STEP)

Robert Briggs, Montana State Systemic Initiative
Lyle Anderson and **Elizabeth Charron**, Montana State University

The Montana STEP collaborative involves five units in our state's university system, seven tribal colleges, school districts, and the State Office of Public Instruction. Project leaders were well aware that to accomplish any kind of mathematics and science reform in the state, they would have to be collaborative and involve all aspects of the system. Montana is the fourth largest state in the United States but has a relatively small, spread-out population, which complicates the desire for collaboration. Therefore, telecommunication was used heavily in our project.

Breaking down human barriers to communication was the next challenge. Elementary teachers did not talk very much to middle school teachers, high school teachers, or university departments in either the education or the scientific disciplines. They certainly did not do a lot of talking across disciplines, between mathematics and science, for example, or any of the other disciplines. Improving communication and coordination among organizations, teachers, and others directly involved with education in sciences and mathematics was a priority.

Meeting the challenge of Standards-based reform has already begun in many states. Current efforts in Montana, Louisiana, and Connecticut were described, not as exemplars, but to stimulate discussion on lessons learned and the potential for adapting successful strategies in other states.

Changing the pedagogical practices of higher education was a necessary condition for changing the pedagogical practices in the K-12 schools. We looked at the universities, our own practices, and our own courses. Originally, we thought that course revision could be accomplished quickly, with new ways of looking at content and new ways of teaching that would also serve as effective models for the future. Our idea was to provide release time for a course revision team during a summer or a semester. Those of you who have been involved in this effort on your own campuses know, as we learned, that course revision takes a long time.

There was also a need to focus on areas that traditionally have been relegated to administrators alone, such as recruitment of new faculty. For example, we urged deans to choose the outstanding researcher who was also an outstanding teacher, and interested in course reform. We now are working with administrators to give promotion and tenure credit for improving instruction, not just research.

As we instituted new and better ways of teaching science, math, and methods courses at the university, we also worked closely with those schools involved in student teaching. The *National Science Education Standards* say that becoming an effective science teacher is a continuous process that stretches across the life of a teacher from his or her undergraduate years to the end of a professional career. The Montana STEP project has developed a beginning teacher support system that works with teachers during student teaching and continues into their first years of teaching. We are now experimenting with this mentoring system in a rural setting.

Finally, we have found that it is extremely important to work harder on articulation agreements between the two-year and the four-year colleges so that a student who starts out or completes a two-year degree at a tribal or community college does not then have to spend four additional years at the university to complete his or her teacher preparation program.

The Louisiana Collaborative for Excellence in the Preparation of Teachers (CEPT)

Kerry Davidson, Louisiana Board of Regents
Linda Ramsey, Carolyn Talton, and **William Deese**, Louisiana Technical University

CEPT first and fundamentally recognizes that significant shifts are required in some long-standing educational values and behaviors—shifts that directly affect stakeholders along the entire K-16 spectrum. Central among them is an understanding that colleges and universities must lead from the center and not follow from the margins. Indeed, it is our view that the K-12 effort will not be sustained without the *Standards*-based reform of undergraduate mathematics and science in general and of teacher preparation in particular. It is clear as well that the way in which graduate students are prepared cannot be left out of the

equation, for what models will these beginning faculty follow as they enter classrooms of future teachers?

Standards-based K-16 instruction, which at its heart centers on activity and inquiry, must be viewed as a connection of links or a seamless web rather than as separate compartments that parallel traditional organizational levels and bureaucracies. An overarching issue for campus renewal grants is to encourage the integration and coordination of course work across disciplines. Continuing reviews of existing academic programs and departments will make certain that subject matter departments under review demonstrate contributions to teacher preparation and undergraduate reform. Education departments under review must demonstrate their bridges with subject matter departments.

The CEPT project at Louisiana Tech is an interdepartmental effort. The main thrust is to develop model pre-service courses, with an instructor from the education department working with his or her counterpart in the content areas. Another goal has been to develop cooperating teacher sites that are supportive of reform-based strategies. There is a lot of emphasis on working with classroom teachers on campus, and then using those teachers for field placements. A side effect is that the idea of different teaching strategies has spread to a group of practicing teachers.

A third part of the project has focused on much-needed professional development for university faculty. This collaborative effort has given a unique opportunity to university faculty that they may not have had otherwise: the opportunity to go to conferences and also to return the following year as presenters. We have brought in speakers who have attracted faculty from across our campus and other campuses to look at issues such as critical thinking skills and how to reform teaching strategies at the college level. Ultimately, math and science must be taught better for all students. Changes in education courses will effect changes in content courses. Faculty who have participated in the pre-service programs already are implementing many of these strategies in courses that are not designed for pre-service teachers. The next step, of course, is to involve all faculty in our undergraduate programs, not just those who work with pre-service teachers.

A strong point is the team-teaching approach in pilot courses. A scientist, a science education specialist, and an outstanding public school teacher are in the classroom together. While this is not realistic for long-term reform, it has been tremendous in helping to see where each person has strengths and weaknesses. One thing the students learn from this experience is that the teacher does not know everything.

It is important that young, nontenured faculty are involved in research, that they publish research, and that they get research dollars. To encourage them to participate in activities to improve course content and teaching, a formal mechanism should exist that shows how this area will be given consideration in the tenure process.

The Connecticut Science Education State Assessment Program (SESAP)

Michal Lomask and **Raymond Pecheone**, Connecticut Department of Education

The SESAP is a new program designed to tie together accountability and support for beginning science teachers in Connecticut. The main goals for the SESAP were articulated as: a) developing an assessment system that can provide worthy information about teacher performance in relation to Connecticut Professional Science Teaching Standards, and b) creating induction programs for beginning teachers to support improvement of instruction and student learning in public schools. In addition, the program aimed to set a coherent vision for science education practices in the state by creating alignment between the program of student high school science assessment and teacher assessment.

Overall, the arching theme of the program is student learning and how to improve student learning through better teaching. But what is "better teaching?" To answer this question, we have to think about the purpose of teaching and what we would like students to do in schools. Establishing a set of standards that describe the vision for excellence in science education was, therefore, the basis for the whole program.

The second step was to articulate what teachers have to know in order to meet the established standards. The SESAP claims that in order to teach well, science teachers should know and respect their students as learners of science, they should have a wide understanding of the content and processes of science, and they should know how to bring students and science together in a learning community.

How can we build an assessment system that can support teachers and provide information about the quality of their performance at the same time? In our program we decided to base the assessment system on self-documented (portfolio materials are written/selected/organized by the teacher), standards-based (portfolio tasks and evaluation criteria are connected to a set of standards), prescriptive (portfolio follows specific guidelines) teaching portfolios. The teaching portfolios are developed by beginning teachers in their second year of teaching, after they participate in a year-long Science Teaching and Learning support seminar program. In their portfolios the teachers document their teaching and provide evidence for the learning of their students in a two-week unit of explorative science. The portfolio contains teachers' daily logs, students' work, videotaped segments of classroom and lab teaching, and teachers' reflective commentary about the quality of their teaching.

Currently, all beginning science teachers in Connecticut participate in a two-year induction program and have to submit a science teaching portfolio in order to receive a provisional science teaching license. Teachers who do not meet the state standards of teaching performance in the second year of their teaching are given an opportunity to improve their teaching and submit a new portfolio in the third year of their teaching. A second failure to meet state standards means termination of teaching in Connecticut's schools.

The teaching portfolio enables teachers to document their teaching and other professionals to evaluate the quality of their teaching. A detailed portfolio evaluation and scoring system was developed, experienced teachers were trained to use the scoring system, and data collected from the scoring process was analyzed to elicit evidence of reliability and validity. Initial studies showed that the portfolio can be reliably scored by trained science teachers. Analysis of scores by background factors, such as gender, school assignment, course content, and school community, did not reveal any differences in performance based on these factors.

In summary, the SESAP, with its support and assessment components, requires investment of time, money, and expertise. These resources are well spent if they translate into better student learning.

Professional development for teachers of science is a continuous, lifelong process. Teachers build skills gradually, beginning with undergraduate experiences. Each component of the education system must support teachers as they move from the pre-service program through their professional career. The continuum of professional growth was examined by a panel that presented the perspectives of the teacher, science professor, science education professor, school-level administrator, and state superintendent. Arthur Wise, president of NCATE and panel moderator, provided the perspective of credentialing agencies.

Reflections on Pre-service Education and Teachers' Needs

William Badders, Presidential Awardee for Excellence in Science Teaching; Cleveland City Schools

Like most elementary teachers, I had virtually no content background in the sciences. I scheduled textbook science at the end of the day but rarely taught it. In 1988, after 18 years of teaching, I became involved with a 4-year project developing, field testing, and piloting the *Insights* curriculum. This was the first opportunity I had to talk seriously about teaching science with others and to reflect on my teaching. We read and reviewed professional papers. We talked incessantly about our teaching, sharing ideas. We grappled with management issues and played around with materials. We had contact with important scientists and leaders in science education. This opportunity to meet and discuss teaching with other teachers does not exist in most school districts.

Applying this experience with kids left me with the realization that I had learned mechanical applications of doing hands-on science, but I did not have a deep understanding of inquiry. My questioning strategies were weak. How do you question? How do you get kids to provide evidence? I lacked the content knowledge needed to guide my questioning. I had not even addressed my own misconceptions about science. But it was a start.

I learned that there was much more I needed to know about teaching: constructivism, pedagogy, classroom management, materials preparation, equity, the learning cycle, and interdisciplinary approaches. I needed to know more about curriculum: age appropriateness, material selection, curriculum planning, state and national goals, and assessment. But I still needed more content.

And that is just in science! As an elementary teacher, I am required to teach all subjects.

Celeste Pea, Presidential Awardee for Excellence in Science Teaching; Louisiana State Systemic Initiative

My undergraduate education was very rich in content. When I left the university I was full of information on biology, chemistry, and physics. I could recite most of the laws of most of those disciplines. However, I did not know how to teach. I did not have what is now called "pedagogical content knowledge." I knew the content, but I did not know how to take content and change it into some format or task to get complex concepts over to my students. I knew how to make lesson plans; that is, I knew what page students should be on given a particular day. But that has very little to do with actually getting knowledge across to the students. I did not have strategies to figure out if students were academically ready for materials that I was trying to present. It became very frustrating to me and to my students. It is one thing to know the content. It is another thing to apply pedagogy to content so that students understand.

Courses for pre-service teachers need to be redefined, rewritten, and re-aligned, keeping in sight the content and the concepts. Methods of teaching must be presented in the context of the science content and in support of it. What is important for teacher preparation programs is the substantiality of the content, not necessarily how many hours are taken in a particular subject. The quality of the content and the methods for presenting it are more important.

As a teaching force we have stolen most of the students' yesterdays. We have their todays under siege, and we are threatening their tomorrows. Unless we change our approach to the content that we are giving, to the pedagogy that we are using, to the experimentation that we are doing, to the validation or the expectation that we have, we can expect no better than we have.

Response to the Teachers' Comments

Arthur Wise, President, National Council for Accreditation of Teacher Education (NCATE)

What we have learned from these teachers is that it is not content **or** pedagogy—it is content **and** pedagogy. It is clear from our speakers' reflections that their early teaching experiences left them somewhat less than fully satisfied with their pre-service preparation. We must think carefully and systematically about how to prepare and support teachers as they develop throughout their careers.

There is a broad awakening that it is time to invest in the intellectual capital of our teachers and to provide for their initial and continuing preparation in substantially more enriching ways than we have in the past. Furthermore, we have learned that it is important to begin the preparation of teachers in college, but it is unlikely that we can fully prepare teachers to teach effectively in the confines of a four- or even a five-year college-based program. Teacher preparation and professional development are and must be lifelong or career-long processes.

We at NCATE welcome the *National Science Education Standards* and are engaged in a series of efforts to change the way teachers are prepared and licensed. I think there is no more difficult problem in teacher education than the proper preparation of elementary schoolteachers. NCATE is embarking on a fresh look at new standards for the preparation of elementary schoolteachers in all fields, including, of course, science.

A Science Educator's Perspective on Teacher Education

Paul Kuerbis, Professor of Science Education, Colorado College

I would like to remind us of the vision for learning and teaching science set by the *National Science Education Standards*. Those of you who have heard me speak before know that I am struggling with trying to invent a single word to describe these inextricably linked phenomena. I call it "learching" because we cannot have teaching unless we have a model of learning, with the two joined together.

So what does it take to produce a good teacher? How can we restructure programs and courses so that teacher candidates are called upon actively to make sense of learning and therefore of teaching? The *Standards* have to be the underpinning of a good teacher preparation program. I remain convinced that there must be early field experience, field-based methods courses, foundation courses that are broadly integrated across college campuses, and extended periods of student teaching.

These structural changes are necessary, but they are not sufficient. Other questions must be addressed. How can pre-service teachers interact with the classroom teacher to learn the craft and the culture of talking, reflecting, and researching? When and how should progressive interactive experiences in diverse classrooms be provided? When should teacher candidates be engaged in reflective practices, analysis of classroom interactions, and classroom-based research? When are they involved in the evaluation of materials, and in the instruction and assessment approaches that are part of the *Standards* and of the *Benchmarks for Science Literacy*?

How do science departments and faculty demonstrate that they value the preparation of teachers? When and how can departments and faculty restructure the curriculum to recognize elements of the *Standards*, major content ideas, inquiry-centered pedagogies, and alternate assessments? These are the kinds of questions that need to continue to be asked and answered in schools of education.

The Role of Undergraduate Science Courses in Teacher Preparation

Patricia Simpson, Associate Professor of Biology, St. Cloud State University

Teacher education in science must be transformed so that teachers will be prepared to teach according to the vision of present and future national standards. Teachers must be prepared to continue learning new content and new ways of

teaching throughout their professional lives. In order for this to be accomplished, it is essential that bridges are built between the education faculty and the content faculty involved in teacher preparation. We tend to know our own area. Discipline specialists know developments in science, but may not know about current recommendations in science education.

The State of Minnesota Framework for Education of Teachers of Mathematics and Science was developed to communicate clearly common, statewide goals for the preparation of teachers in mathematics and science. The framework describes five areas important to teacher preparation programs that will transform teacher education: content, pedagogy, students, an environment for learning, and the process of professional development.

Within each of those five areas, the framework addresses four questions. First, "What are the knowledge and skills individuals need to acquire?" Second, "What are the experiences that these individuals need to have in order to acquire those knowledge and skills?" Third, "What are the roles and responsibilities of faculty throughout the university?" And fourth, "What are the characteristics of a university that produce accomplished beginning teachers?"

Teachers are the key to effective reform in science and mathematics education. The education of mathematics and science teachers is the responsibility of an entire institution, and the successful transformation of science and mathematics education will require strong and sustained support from many individuals over time. For example, convincing the dean of a college of science and technology to buy into the necessary changes for educating teachers implies change within the entire college. The dean must understand that in the end, successful efforts to reform teacher preparation programs ultimately will enhance the education of every student who attends the university.

When working with stakeholders from different communities, we must remember that everyone is an expert in a different area and has ideas that need to be valued. One of the most important messages to take away from this conference is the need to establish communities of learners composed of all the individuals involved in teacher preparation. The first step in building this community of learners is to establish an environment of trust and respect within and between university colleges, departments, and the local K-12 teachers and administrators.

A Principal's Perspective on the K-12 School's Role in Preparing Teachers

Mary Ann Chung, Principal, Sunrise Valley Elementary, Fairfax County, Virginia

In the Fairfax County Public School system, each elementary school has lead teachers for science, social studies, and mathematics. Lead teachers attend in-depth programs and then are supposed to provide turn-around training in

their own schools. But at the school level, principals still need to provide that precious resource of time. Turn-around training is not effective when it is reduced to one after school in-service. Where do the teachers find the time to learn new teaching strategies, let alone the time to create visions? My vision was to meet the professional development needs of teachers in my building within the time constraints of the school day.

At Sunrise Valley Elementary, the staff had worked together for a long time. There was a climate for readiness—to think about how to reduce the pupil/teacher ratio and to provide opportunities for teachers to create visions and to grow as professionals. We developed strategies to create a "community of learners" by way of a partnership with Marymount University, establishing a professional development academy at our school. Creating this academy—a community of learners—has resulted in some wonderful achievements. For example, there is one intern for every teacher in our building. That intern stays with the same teacher all year long, not just for six or twelve weeks, and has the opportunity to be totally immersed in the school environment.

The teaching staff wanted professional development, and the interns helped make it possible. Once the interns becam accustomed to the students and the routines of the class and the content, they could supervise the classrooms, enabling teachers to have professional development activities right there at the school site during their regular contract hours.

The interns are also learning. They are learning from the sophisticated questions experienced teachers ask in their own staff development sessions and from the teachers as they apply their pedagogical content knowledge. The teachers have the opportunity to go back minute by minute, reflecting on their practice. They think about why they did something when they answer the intern who asks, "How did you ever make that child do whatever?" or "I have been working with Jimmy for two days, and he still has not learned fractions. How can I improve?" Both the intern and the teacher are constantly reflecting and learning.

Education professors are out in the school every day. They come to the school in the afternoon to teach their university courses. They send a coordinator or director of the elementary program out one day a week. We all meet together regularly, and the teachers and interns constantly assess the program and make changes.

One of the comments interns have about the experience is that while they were in the university setting, they would be asked to design lesson plans, but there was no audience, no way to test the plan, and no need to refine it. They were creating in a vacuum. Now they are in the school setting. When they design a lesson, the interns learn both to implement and assess the plan. They also can reflect on how well it works.

A Perspective on the State's Role: Motivation and Policy

William Randall, Colorado Commissioner of Education; President, Council of Chief State School Officers

About a year and a half ago, my wife and I team taught a course at the University of Colorado at Denver for education students, just before they did their student teaching. Reflecting on this course led me to believe that there has not been a lot of substantive change in teacher education in the past 30 years. These students were still struggling with some of the fundamentals of classroom management. They were struggling with the issue of conveying the materials they knew: "Do I just tell students what I know?" How do future teachers learn to teach rather than just "tell?"

In Colorado there are two ways in which we are approaching this issue from the state level. First, there is our licensure program, which is brand-new. Second, there is our State Systemic Initiative (SSI), which involves partnerships between school systems and institutions that prepare teachers. One thing we have learned is that by forcing people to have joint responsibility for programs, there is a different product and a different level of involvement than if it is just "collaborating." People who work in our teacher licensure department are involved with accreditation in areas that do not directly involve their specific job responsibility. They are sharing responsibility. People do not go to meetings and say, "Well, we collaborated." They say, "I am responsible for the success of this venture." That responsibility carries over into action that makes a difference.

We believe that if we break down the barriers within the state through the SSI, we can work with higher education, with the school systems—with anyone else—and say, "We have a joint responsibility for the success of this venture that is based on student achievement." If we have joint responsibility, then we all have to make sure it happens. Unless we have that mind-set going in, we are going to have a lot of difficulty carrying out the reforms, no matter how well organized, no matter how well structured, and no matter how great the content is.

Concern, Collaboration, Coordination, and Communication

Jane Butler Kahle, Co-principal Investigator, Ohio Statewide Systemic Initiative (SSI)

The last page of the *National Science Education Standards* strikes at the heart of a major dilemma in the current call for system-wide, *Standards*-based reform. In the discussion of system standards, the problem of educating teachers who are able to think and to teach in ways that will promulgate the content, pedagogical assessment, and program standards is addressed. I quote, "In higher education, two- and four-year college professors need to model exemplary science pedagogy and science curriculum practices." That is, teachers need to be taught science in college in the same way that they, themselves, will teach science in school. The

next sentence presents the dilemma: "The culture of higher education is such that the requisite changes will occur only if individual professors take the initiative." This passage continues on to mention superficially roles of administrators. But the onus of change is placed on individual faculty members. The roles of policy makers, particularly those who license and credential teachers, are not explicated. Yet both university administrators and state officials play important roles in the preparation and professionalization of teachers.

Concern Prospective teachers have little, if any, experience with the type of teaching that is espoused in the *Standards*. In fact, their experience is described in the *Standards* in the following way: "Undergraduate science courses typically communicate science as a body of facts and rules to be memorized, rather than a way of knowing about the natural world. Even the science laboratories in most colleges fail to present science as inquiry. Moreover, teacher preparation courses and in-service activities frequently emphasize technical skills."

Jane Butler Kahle's presentation on Standards *and teacher preparation, which preceded the final state team planning session, focused participants back on the issues for teacher preparation raised by the* Standards *and on the scope of involvement by the education community required to bring about change.*

Furthermore, science teacher educators, the majority of whom are over 50 years of age, have little if any, experience with the type of teaching espoused in the *Standards*. Yet they are supposed to encourage their student teachers to teach according to the *Standards*. Last, and perhaps of lingering concern in this country, elementary teachers continue to have little experience with any kind of science. In 1993, only two out of three elementary teachers had at least one college course in the biological, physical, and earth sciences. Therefore, I want to take a minute to explore with you the dichotomy between what the *Standards* say should be taught and what teachers can teach.

First of all, the *Standards* say we must have high expectations for all students. Second, the *Standards* call for a focus on in-depth learning of a limited number of powerful concepts, with an emphasis on reasoning and problem solving rather than on memorizing facts, terminology, and algorithms. Third, teachers are to integrate the nature and processes of science and mathematics inquiry with a knowledge of science and mathematical concepts and principles. Fourth, teachers are to engage students in meaningful activities that enable them to construct and apply their knowledge of key science and math concepts. Fifth, teachers are to teach in a way that reflects sound principles from research on how students learn, including using cooperative learning and questioning techniques that promote interaction and deeper understanding. And finally, sixth on my list, teaching is to incorporate appropriate and ongoing use of calculators, computers, and other technologies in science and mathematics.

That is the vision of what our science teachers should be doing. Let us now contrast those expectations with what research tells us about teachers:

- Over one-half of the science and mathematics teachers do not feel prepared to use computers as an integral part of instruction.
- Over one-third of all elementary teachers and one-half of all high school teachers feel unprepared to involve parents in the science education of their children.
- Roughly 40 percent of all science and math teachers lack the preparation to use performance-based assessment.
- About one-quarter of all science and math teachers feel poorly prepared to use a textbook as a resource rather than as the primary instructional tool.
- One-third of all science teachers feel poorly prepared to take into account children's prior conceptions of natural phenomena when planning curriculum and instruction.

The preparation of teachers must close this gap between the expectations of the *Standards* and the reality of practice.

Collaboration We need radical changes in pre-service science teacher preparation. In fact, we are faced with the need for radical changes in two fairly recalcitrant populations: science faculty, who teach undergraduate science courses, and education faculty, who teach methods courses and supervise field experiences. These changes call for massive collaboration. One example of the need for collaboration is provided by the promulgation of the University of Washington's *Physics by Inquiry* course throughout one state as part of its Statewide Systemic Initiative (SSI). The course was developed to provide prospective teachers with in-depth inquiry experiences in physical science; the SSI has adapted it to practicing teachers. Individual faculty members in about 15 universities across Ohio now use *Physics by Inquiry* as a physics course for in-service teacher professional development, and individual faculty members in about 18 colleges and universities across the state are using pieces of it in their physics courses or in their science methods courses. Yet it has been institutionalized into the teacher education program at only one institution. Why? Although the course is widely discussed among science faculty, many education faculty members do not understand how it is different from the physical science courses traditionally offered in pre-service programs.

The chasm separating the arts and science faculty from the education faculty is deep and wide. Bridging it will require active initiation and support at both the dean and provost levels. With *Physics by Inquiry,* an individual faculty member took the initiative as recommended in the *Standards.* But that step has not been and will not be enough. The risks are too great for individual faculty members to undertake such actions unilaterally. On-campus collaboration may be easier

to achieve at the dean level than the faculty level, and faculty members must see evidence of that collaboration as well as support for it from all administrative levels.

There are two reasons why it is difficult to reach collaboration. First, it is much more costly to teach *Physics by Inquiry* than a lecture course in introductory physics. Physical science for elementary teachers historically has been one of the college of education's highest enrollment courses, bringing in lots of state support. Historically, it also has been a traditional course taught by a science educator in a way that epitomizes the classic lecture and the cookbook laboratory. The second issue is time. Where do you spend your time when the university is going to reward your research, not your teaching, record? Without incentives for change at the highest levels of the university—promotion, tenure, and release—individual faculty initiatives will not result in program change. Individual initiatives will not affect teacher preparation in a systemic and sustained way. Essentially, senior faculty and administration must promote and accept the needed changes, validating them through the reward system of promotion and tenure.

Coordination Local and state agencies also must play a critical role in coordination. The science teaching standards call for "coherent and integrated professional development programs." International studies suggest that opportunities for teachers to discuss content and pedagogy as part of their teaching day result in both better teaching and enhanced learning. Examples of the approach advocated may be found in other countries that have allocated educational funds to have better educated and better paid teachers, countries in which teachers comprise virtually all of the employees in schools, and countries where teachers make most of the curricular and teaching decisions. While fewer than one-half of all public education employees in the United States actually are teachers, more than three-quarters of all education employees in Australia and Japan are teachers, and more than 80 percent of education employees in Belgium, Germany, the Netherlands, and Spain are teachers.

In the past, heavy administrative oversight of teaching has led to reduced investments in the professional education of teachers and teaching activities. Because the competency of teachers has been questioned in the past, we have developed a system of supervisors and specialists to manage, practice, and administer a wide array of special programs. In fact, between 1950 and 1990, the proportion of public school staff who actually taught declined by 17 percent. Only coordination among local and state stakeholders can begin to address changes that are focused on the improved preparation of teachers and on increased teacher responsibility for education of students.

Communication Neither teacher preparation nor professional development has tackled the difficult issues of assisting teachers in understanding how children and adults actually learn science. Although this issue is not a prominent

one in the *Standards*, it is a critical one if teachers are to provide developmentally appropriate activities, examples, and exemplars. Research in cognitive science and other areas of science education has begun to explicate how children process knowledge, how they construct concepts, and why they cling to prior conceptions. Both in-service and pre-service teachers need to see their classrooms as laboratories in which they can study the teaching and learning of science.

The insights gained through thoughtful observation, analysis, and assessment will contribute to improved practice and to the professionalization of teacher preparation. There has been over a decade of research about the learning of mathematics. Mathematics teachers and researchers have worked together to develop, test, and revise mathematics curricula and materials based on that knowledge. Now it is being applied directly to the creation of cognitively and developmentally appropriate *Standards*-based curricular materials. A great deal more is known about how children and adults learn mathematics compared with science, and we need research that addresses the learning of science to improve the preparation of teachers.

The need for better curriculum materials in the science education community must be communicated in the strongest possible way to policy makers, publishers, foundations, deans, and faculties. Science education does not have the research base to proceed into the same kind of validated curriculum development that is going on in mathematics.

The *National Science Education Standards* are dynamic, creating change as change occurs. They will continue to evolve, and they will need to be revisited as ways to extend them into teacher preparation, credentialing, and professional development are designed. Such activities will bear fruit only if they involve collaboration and coordination and if they are communicated to the multiple constituencies involved.

Response to Dr. Butler Kahle from the State Perspective

Terry Janicki, California Commission on Teacher Credentialing

The *Standards* will not be implemented if we cannot find better ways of involving undergraduate science faculty. We need to find better ways of getting science professors to use inquiry-based methods in their work. A role for credentialing agencies is to provide some of the leverage to make the changes that many faculty members would like to make but that as individuals they cannot. They need the leverage of their administrators or the money to make the changes.

It is important to talk about the collaboration needed between the K-12 community and the higher education community. One of the biggest changes coming up in California is a joint governance over teacher education. The K-12 community in California is now saying that they should be partners in the education of teachers, not just once they get in the classrooms and in the in-service programs

but right from the beginning. State agencies and credentialing agencies can do much to assist in that partnership by asking colleges and universities to involve directly the K-12 community in a much more focused way.

In California we have a program called the "Beginning Teacher Support and Assessment System," in which beginning teachers are supported during the first year or two in the classroom. We see this as the second part of teacher preparation: the training that is needed on the job. These programs are working effectively in the schools in which the K-12 administrators and the higher education institutions have decided to work together to make the changes happen. Based on this collaboration, we are finding that the K-12 community is much more interested and much more able to be involved in undergraduate teacher preparation.

Communication is a critical issue. Credentialing institutions can leverage what beginning teachers know and the ways in which they are taught. But what leverage can be used to benefit existing teachers in the classroom? We hope that mentors for beginning teachers can become catalysts for change in their own locales.

Credentialing agencies can work in this area through the requirements for professional development. In California, 150 clock hours are needed every five years for continued certification. The credentialing agencies can focus those 150 hours in more individual ways. We are not able to now, but in the future we will be able. For now, we have to communicate to the existing teachers the changes that are needed in science instruction.

Participant Comment

Corrine Hill, Education Policy Adviser to Utah Governor

You need to get to the governors in your states. At the educational summit in New York on March 26th and 27th, the governors are going to talk about world class standards, assessment, and technology as ways to reform education. But I do not know that all of our governors know what a standard is. Make an appointment with your governor, and explain what standards are about. We are doing a wonderful job, and we are moving ahead. But I urge you to spend some time with your governor. Let him or her know where you are moving in science education and what you need. It is money, and it is legislation. That is what drives policy.

Closing Remarks and Challenge for Next Steps

Virginia Pilato, National Association of State Directors of Teacher Education and Certification (NASDTEC)

NASDTEC has a long history of writing and using process standards. NASDTEC now is saying that we cannot, at least for the present, continue developing standards, but its position supports the promotion of performance-based state or

This symposium succeeded in identifying the need for improvement in teacher preparation and credentialing. Change will require long-term commitment and effort.

nationally developed standards. Content and teaching standards are being developed by subject area specialists. We need to see their fit; NCATE needs to bring them all together, providing leadership in teacher preparation in this systemic reform. This symposium is about the national organizations coming together, including NASDTEC, NCATE, the National Board for Professional Teaching Standards, and INTASC (the Interstate New Teacher Assessment and Support Consortium). This symposium is also about the children. One of the main impressions we have as we wind up these two days together is the picture of children from this morning's video. A little girl told her teacher she sees herself as a scientist. Our long-range goal is for children to say that. This morning we looked at the future.

Steps in the movement toward this future, according to Dr. Bybee's overheads, begin with purpose, move to policy, from there move to program, and finally end with practice. Dr. Bybee said we are poised at policy and program. Another way to look at this is that we are poised at the implementation phase, the point at which we can bring all of this to life to make the change.

Larry Cuban, who studied the implementation of technology, said that we must find the fit with our routines. Otherwise, the innovation will not be used. We must discover how the *National Science Education Standards* fit with our reforms, or else our innovation will sit on the shelf. When the fit is found, the *Standards* can be a tool of our reform. Another person whose work I draw upon is computer scientist Edward Feigenbaum, who says, "We must be champions for our innovations."

We must be champions for the *Standards* and sometimes we must do so at a personal level. Do not throw the *Standards* over the wall and hope that the document will be picked up and used. We must reach out to professional development—pre-service and in-service—and to the systems into which the *Standards* will fit. We must be champions for change and for the use of these *Standards*. We must look for ways to broker the fit and cheerlead for the *Standards*. We must promote excitement about the work that has gone on before us.

Looking to the Future

Council of Chief State School Officers

The Council has a strong commitment to future use of standards in forming education policies and offers several continuing activities that provide ongoing methods of work with states on preparation and credentialing of teachers in science:

- The Interstate New Teacher Assessment and Support Consortium (INTASC) of state education agencies, higher education institutions, and national educational organizations is promoting standards-based reform of teacher preparation, licensing, and professional development. In March 1996, an INTASC committee was formed to work on writing model standards for licensing teachers of science. Science educators are strongly represented on the committee for initial outlines for standards.
- The Council is currently working with state level science and math educators and researchers on a cross-state analysis of state standards and curriculum frameworks. The Council's aim is to provide states with a method of sharing information on current practices and to show examples of how frameworks can be linked to state policies, including teacher education, licensing, and professional development. The Council will prepare a report that identifies common issues across states in developing and using state standards for content of science and mathematics education.

William Randall, *Symposium Co-chair*
President, Council of Chief State School Officers

Association for the Education of Teachers in Science

The Association has as its primary mission the promotion of leadership in and support for those involved in the professional development of teachers of science. We are, therefore, highly supportive of efforts to improve the preparation of teachers

of science whether that be through more coherent preparation programs, improvements in undergraduate science coursework, or changes in how schools of education work with the K-12 sector. AETS has initiated the following efforts to ensure that the *National Science Education Standards* are fully implemented in the near future:

- Formation of an ad hoc committee to work with the INTASC efforts of CCSSO to ensure that the recommendations that emerge are promulgated among our members.
- Establishment of an ad hoc committee on the implementation of the *National Science Education Standards*, with particular emphasis on working closely with the Committee on Undergraduate Science Education of the National Research Council as it examines programs that provide initial preparation of science teachers.
- Participation on a combined committee of the National Science Teachers Association and NCATE to re-examine standards for the licensing of science teachers. This effort, the Certification and Accreditation in Science Education, is fully supported by AETS, with contributions by our members who currently serve on that committee.

Paul Kuerbis, *Symposium Co-chair*
President, Association for the Education of Teachers of Science

National Research Council

The Center for Science, Mathematics, and Engineering Education continues to place priority on the issues around professional development of teachers of science. The Committee on Undergraduate Science Education is preparing a letter report on the state of teacher education for release in 1997. During the next three years, the Division on Post-Secondary Education will be undertaking the following projects:

- *Deepening Understanding about Mathematics and Science Teacher Preparation* will look at the status of teacher education practice and describe the students, faculty, and programs within the system. Products will include a brochure targeted at scientists, mathematicians, and engineers; a synthesis of recommendations, exemplary programs and statistical indicators; and a report that summarizes the current nature of graduate education nationally in mathematics and science education.

- *Improving the Practice of Mathematics and Science Teacher Preparation* will address the mathematics and science content that teachers at different levels should know, how they come to know it, the practice and nature of mathematics and science they need to know, and how the knowledge of mathematics and science relates to teaching practices.
- *Enhancing the Infrastructure for Mathematics and Science Teacher Preparation* is designed to engage college and university presidents, state policy makers, and members of the National Academy of Sciences in becoming more visible players in teacher preparation reforms and to use their influence to enhance the teacher preparation infrastructure. A major component is designed to help science, mathematics, engineering, and technology departments clarify their thinking about the scholarly work that supports teaching and teacher preparation.

Rodger Bybee
Executive Director, Center for Science, Mathematics, and Engineering Education

Appendix A
Agenda

Sunday, February 4, 1996 Wyndham Bristol Hotel

6:30 p.m. **Registration & Light Hors d'Oeuvres**

7:00 p.m. **Introductions and Overview of Symposium**
Gordon Ambach, *Council of Chief State School Officers*
Rolf Blank, *Council of Chief State School Officers*
Joyce Weiskopf, *National Science Education Standards Project*

8:00 p.m. **State Team Planning Session**

Monday, February 5, 1996 National Academy of Sciences

8:00 a.m. **Welcome**
Bruce Alberts, *National Academy of Sciences*
Robert Watson, *National Science Foundation*
William Randall, *Council of Chief State School Officers*

8:15 a.m. **Implications of the *Standards* for Teacher Preparation and Certification**
Pascal Forgione, *Delaware State Department of Education*
Respondent: Angelo Collins, *Vanderbilt University*

9:00 a.m. **Overview of the *National Science Education Standards***
Rodger Bybee, *National Academy of Sciences*
Susan Loucks-Horsley, *National Center for Improving Science Education; WestEd*

10:15 a.m. **Discussion Sessions with Standards Working Group Members**
Assessment and Content
Frances Larwenz, *University of Minnesota*
Facilitator: Robert Ridkey, *University of Maryland*
Professional Development
Susan Loucks-Horsley, *National Center for Improving Science Education; WestEd*
Facilitator: Paul Kuerbis, *Colorado College*
Program and System
Harold Pratt, *BSCS*
Facilitator: Angelo Collins, *Vanderbilt University*

11:45 a.m. **State Team Planning Session**

12:30 p.m. **Box Lunch**

1:30 p.m. **Science Education Reform: What is Currently Happening?**
Panel Discussion

Montana	Robert Briggs, & Elizabeth Charron, *Montana State University*
	Lyle Anderson, *Montata State Systemic Initiative*
Louisiana	Kerry Davidson, *Louisiana Board of Regents*
	Linda Ramsey, Carolyn Talton, & William Deese, *Louisiana Technical University*
Connecticut	Michal Lomask & Raymond Pecheone, *Connecticut Department of Education*
Moderator:	Joan Ferrini-Mundy, *National Academy of Sciences*

4:30 p.m. **Discussion Sessions with Panelists**

Montana	Bruce Dichau, *College of St. Benedict*
	Patricia Simpson, *St. Cloud State University*
Louisiana	Robert Fischer & Michael Kurz, *Illinois State University*
Connecticut	George Nelson & Rodger Olstad, *University of Washington*

5:30 p.m. **State Team Planning Session**

Tuesday, February 6, 1996

National Academy of Sciences

8:30 a.m. **Integral Role of the System: Supporting the Teacher**
Video

9:00 a.m. **Overview of the Teacher Preparation Continuum**
Panel Discussion

Teachers:	Celeste Pea, *Louisiana State Systemic Initiative*
	Bill Badders, *Cleveland City Schools*
Science Ed Professor:	Paul Kuerbis, *Colorado College*
Science Professor:	Patricia Simpson, *St. Cloud University*
School Principal:	Mary Ann Chung, *Fairfax County Schools*
State Superintendent:	William Randall, *Colorado Department of Education*
Moderator:	Art Wise, *National Council for Accreditation of Teacher Education*

11:00 a.m. **Discussions with Panelists**

Celeste Pea, *Louisiana State Systemic Initiative*
Bill Badders, *Cleveland City Schools*
Facilitators: Linda Ramsey & William Deese, *Louisiana Technical University*
Paul Kuerbis, *Colorado College*
Facilitators: Penny Moore, *University of California, Berkeley*
Nancy Devino, *National Academy of Sciences*
Patricia Simpson, *St. Cloud University*
Facilitators: Robert Fisher & Michael Kurz, *Illinois State University*
William Randall, *Colorado Department of Education*
Facilitators: George Nelson & Roger Olstad, *University of Washington*
Mary Ann Chung, *Fairfax County Schools*
Facilitators: James McMillan & Randy Hitz, *Montana State University*

12:00 p.m. **Lunch**

1:00 p.m. **Standards and Collaboration: Keys to Teacher Preparation**
Jane Butler-Kahle, *Miami University*
Respondent: Terry Janicki, *California Commission on Teacher Credentialing*

2:00 p.m. **State Team Planning Session**

3:00 p.m. **Sample State Team Plans**
Moderators: Tom Keller, *Maine State Department of Education*
Karen Reynolds, *San Jose State University*

4:30 p.m. **Closing Remarks and Identification of Next Steps**
Virginia Pilato, *Maryland Department of Education*

Appendix B
Action Plans Prepared by State Team Members

Alaska's Action Plan

Team Members	Agency or Institution	Position
Peggy Cowan	Alaska Department of Education	Science Specialist
Robert Gottstein	Alaska State Board of Education	Teacher Certification
Alexander McNeill	University of Alaska - Anchorage	Dean, School of Education
Paul Reichardt	University of Alaska - Fairbanks	Dean, College of Natural Science

Existing policies and practices that support the *Standards*:
- State Science Standards (voluntary)
- State Framework Documents and Projects
- State Teacher Standards

Existing policies and practices in need of change:
- Current licensure allows certified teachers to teach in any content area or grade level
- No monitoring of accreditation requirements for individual K-12 schools
- No content area requirements for endorsement
- Preparation of rural teachers

Key players in implementing change:
- Legislature
- Governor
- Alaska Association of School Administrators
- NEA/Alaska Science Teachers Association
- IHE's - University of Alaska, Sheldon Jackson, APU
- Alaska Department of Education
- State Board of Education Professional Certification Task Force
- University of Alaska Rural Education Task Force

State goals for improving science teacher preparation:
- Examine existing state policies/procedures in light of the *Standards*
- Use state and national standards to redesign science teacher preparation and science requirements for elementary education
- Stage process for licensure

To accomplish these goals, the following actions are planned:

Within six months
- Add-on assignment to existing frameworks teacher preparation committee with intent of influencing Board of Education Professional Certification Task Force
- Frameworks sponsored workshop on science/math standards and teacher preparation for university faculty
- Explore models for staged licensure

During the next twelve months
- University of Alaska sponsored (in principle and dollars) task force on reform of science/math teacher preparation:
- Develop Alaska plan for staged licensure

Over the next two years
- Board of Education Professional Certification Task Force report to Board of Education—lobby for *Standards*-based on certification and licensure
- Develop individual institutions' reform plans
- First point will include staged licensure

By the end of five years
- Reformed teacher preparation in science/math
- Fully implemented

Arkansas' Action Plan

Team Members	Agency or Institution	Position
Donna Elliott	Arkansas Department of Education	Program Manager
Suzanne Mitchell	Arkansas Statewide Systemic Initiative	Project Director

Existing policies and practices that support the *Standards*:
- Act 236 - Education Reform Act
- Act 453 - Science/math Equipment Act
- Science Curriculum Frameworks
- Task Force on Teacher Licensure and Certification

Existing policies and practices in need of change:
- Teaching certificates in many areas of science
- Pre-service science and science education courses
- Alternative certification practices
- Add-on endorsements

Key players in implementing change:
- Members of Task Force on Teacher Licensure and Certification
- Department Chairs of science departments (and other subjects) and professors
- Deans of Education/Arts and Sciences; Presidents of colleges and universities
- Director of Arkansas Department of Education and Department of Higher Education
- State Boards of Education and Higher Education
- Curriculum specialists in science (and other subjects)
- Coops (Education Service Cooperatives)
- Teachers, Principals, Superintendents, School Boards
- Parents and business leaders, Arkansas Education Association

Primary goals for improving science teacher preparation:
- Arkansas will change its teacher licensure and certification process

Secondary goals for improving science teacher preparation:
- Arkansas will work with NCATE and the new Professional Development Teaching Models (2 year)
- Arkansas will develop subject specific outcomes to improve teacher licensure
- Arkansas will change the assessment system for obtaining a teaching license

To accomplish these goals, the following actions are planned:

Within six months

- Host eight one-day new professional teacher model sessions at eight universities (Fall 1996/Spring 1997)
- Host a two-day conference for all college science departments (Summer 1996)
- Host cluster groups in subject areas to develop what teachers should know and be able to do in subject areas (Summer 1996)

During the next twelve months

- Host an additional eight one-day new professional teacher model sessions at eight more universities (Fall 1996)
- Explain teacher licensure changes, science and math standards, and systemic initiatives to field representatives at the Arkansas Department of Education, superintendents, and educational cooperatives
- Develop information dissemination methods (WWW, public forums, newsletters, etc.)
- Present teacher licensure information to participants at the Leadership Academy for principals and other state leaders
- Continue working with university collaboratives that are developing the new teacher licensure assessment system for beginning teachers (initial license and professional license)

Over the next two years

- Develop the recertification process and an advanced licensure process to be facilitated and overseen by the Arkansas Department of Education

By the end of five years

- Have the restructured licensure system up and running, yet evolving continually to better service teachers and students

California's Action Plan

Team Members	Agency or Institution	Position
Bonnie Brunkhorst	California State University - San Bernardino	Professor, Science Education and Geology
Jerrilyn Harris	California Commission on Teacher Credentialing	Science Teacher
Terry Janicki	California Commission on Teacher Credentialing	Staff Consultant
Penny Moore	Piedmont High School	Teacher
Kathleen O'Sullivan	San Francisco State University	Professor
Karen Reynolds	San Jose State University	Director, Elementary Education
Erwin Seibel	San Francisco State University	Dean, Undergraduate Studies
Vivian Lee Ward	Genentech, Inc.	Teachers' Coordinator

Existing policies and practices that support the *Standards*:

- California K-12 Science Framework since 1990, based on principles in Benchmarks and Project 2061 (but need history of science and technology)
- Professional development projects at many levels
- Commission on Teacher Credentialing and legislative support
- Secondary credentialing now requires science teachers to have coursework in all four major sciences and much more (see CA Single Subject Matter Preparation Program)
- CLAD (Cross-cultural Language Academic Development), ESL
- SDAIE (Specially Designated Academic Instruction in English
- Addresses needs of multi-cultural, multilingual population
- Technology competence

Existing policies and practices in need of change:
- Greater support for middle level teachers or greater effort to support this population within existing structure
- Greater content base for elementary teachers
- Balance of subject matter emphasis within elementary teacher preparation (science drastically underrepresented)
- Review and revise nature of modeling subject matter preparation in undergraduate science courses

Key players in implementing change:
- Higher education teacher education departments in collaboration with undergraduate science programs and state commissions on teacher certification reform
- California State Department of Education
- Commission on Teacher Credentialing
- California Teachers Association
- California Science Projects
- California Association of Supervisors and Curriculum Developers
- California Science Teachers Association
- Public Opinion
- All California science teachers

State goals for improving science teacher preparation:
- SB 1422 committee to restructure teacher credentialing for the state to coordinate licensure, legislature initiatives, frameworks, universities and science standards into a K-16 lifelong learning continuum
- Strengthen methods - field experience connections (e.g. PDS's)
- Integrate multi-cultural/multilingual needs in science, and vice versa
- Develop spectrum of affective assessment strategies that respond to student learning, teacher reflection, etc.
- Public outreach
- Improve communication among players

To accomplish these goals, the following actions are planned:

Within six months
- Team meeting (reconvene March 9th)
- Plan convocation of key science educators statewide and perhaps regional: focus on *Standards* as vehicle for confirming continual progress and reinforcing further change
- Plan public outreach

During the next twelve months
- Statewide retreats/symposia to support exchange of ideas and Action Planning among stakeholders
- Introduce *Standards* to Commission on Teacher Credentialing, State Board of Education
- Spread the word to science instructors at all levels
- Set up assessment

Over the next two years
- Develop multi-faceted approach to continued development, including public information technology in the service of change
- Think assessment-in-the-service of reflection and self improvement/professional development
- Review assessment

By the end of five years
- Know what we have done

Colorado's Action Plan

Team Members	Agency or Institution	Position
Mary Gromko	Colorado Department of Education	State Science Consultant
Jay Hackett	University of Northern Colorado	Professor, Science Education
Paul Kuerbis	The Colorado College/AETS	Professor/President
Mark O'Shea	Metropolitan College of Denver	Director, Education
William Randall	Colorfado Department of Education	Commissioner

Existing policies and practices that support the *Standards*:
- State Science Content Standards legislated by HB 93-1313
- Local district standards legislated by HB 93-1313
- Colorado Assessment System legislated by HB 93-1313
- Revised teacher licensure rules
- SCASS Science Assessment
- Colorado New Standards Project
- NSF-supported projects including CONNECT (SSI)
- RMTEC, ISTEP
- AAAS/MacArthur Project

Existing policies and practices in need of change:
- Pre-service content science courses and science education courses
- Additional science content for K-6 teachers
- Interaction of science and science education faculty
- Implementation of HB 96-1219: Higher Education
- Quality Assurance Act
- Align district curriculum, instruction, assessment and professional development with district standards

Key players in implementing change:
- Legislature
- Governor
- CASE (Colorado Association of School Executives)
- Colorado Science Education Associations
- CDE
- CONNECT (SSI)
- Science Professional Development Group
- Institution of Higher Education
- Local School Boards
- Colorado Commission of Higher Education
- Task Force on Teacher Licensure

State goals for improving science teacher preparation:
- Examine existing state policies/procedures in relation to state K-12 content and licensure standards
- Use state and national standards to redesign science teacher preparation and science requirements for K-12 science education
- Provide professional development opportunities for K-16 community

To accomplish these goals, the following actions are planned:

Within six months
- Revision of science endorsement standards for secondary
- Provide science leadership and professional development opportunities

During the next twelve months
- Develop long range professional development plans by CONNECT for science and mathematics education
- Provide a series of science leadership professional development opportunities (includes administrators)
- Hold teacher education conferences on *Standards* for discussion on interface between K-12 and higher education
- CONNECT hosts "best practices" conference on *Standards*-based education
- Host meeting for higher education partners of the AAAS/MacArthur teacher preparation grant on use of Project 2061 tools for science education reform
- Host higher education Summit Meetings on *Standards*

Over the next two years
- CONNECT assists collaboratives to implement long range professional development plan for science and mathematics education
- Continue to provide an ongoing series of science leadership professional development opportunities to build leadership capacity within Colorado
- CONNECT hosts "best practices" conferences on *Standards*-based education throughout the state
- Host a series of meetings for partners of the AAAS/MacArthur grant to discuss learnings and reflect on best practices

By the end of five years
- Reform teacher preparation in science and mathematics
- Create ongoing dialogue on best practices in science education, K-16
- Have higher student achievement in science in Colorado
- Sustain effort of systemic reform in science education

Connecticut's Action Plan

Team Members	Agency or Institution	Position
Barbara Kmetz	Trumbull Public Schools	Curriculum Coordinator
Michal Lomask	Connecticut Department of Education	Education Consultant
Robert Lonning	University of Connecticut	Assistant Professor
Raymond Pecheone	Connecticut Department of Education	Bureau Chief
Steve Weinberg	Connecticut Department of Education	Science Supervisor

Existing policies and practices that support the *Standards*:
- Two year induction program to beginning science teachers, culminating in portfolio-based assessment, based on a set of science teaching standards similar to the *Standards*
- A new curriculum framework, partially based on the draft *Standards* performance component on the 10th grade science test
- Statewide 10th grade performance-based science assessment.

Key players in implementing change:
- Higher education science educators
- State agencies
- Teacher organizations

State goals for improving science teacher preparation:
- Establish professional development schools for math and science, in which student-teachers can do their internships

To accomplish these goals, the following actions are planned:
- Goals 2000 grants to start planning

  Within six months
  - Review/apply *Standards* to state frameworks
  - Statewide conference for teacher education faculty to review portfolio assessment and standards

  During the next twelve months
  - Involve professional teacher and supervisor associations in implementation procedures for the *Standards*

  Over the next two years
  - Start a graduate course in science education co-taught by experienced science teachers and higher education professors

Delaware's Action Plan

Team Members	Agency or Institution	Position
Joyce Budna	Department of Public Instruction	Associate for Certification
Jack Cairns	Department of Public Instruction	Education Associate
Pascal Forgione	Department of Public Instruction	State Superintendent
Joan LaGrasse	Department of Public Instruction	Education Specialist
Bill McIntosh	Delaware State University	Professor
Marcia Rees	Department of Public Instruction	Education Associate
Julie Schmidt	University of Delaware	Science Director, SSI
Sandy Wolford	Department of Public Instruction	Field Agent
Rachel Wood	Department of Public Instruction	Education Specialist

Existing policies and practices that support the *Standards*:
- Student Science Curriculum Framework
- Dissemination effort to distribute *Standards* and provide materials to elementary teachers-Smithsonian Project and Van Project
- Itinerant Teacher Project—staff development at district level
- Discus Initiative - facilitate reform at the college level
- Study of science certification standards
- Statewide performance assessments (in development)

Existing policies and practices in need of change:
- Science certification standards under review
- Long range: performance-based certification
- induction/mentoring/recertification
- NCATE partnership (in development)
- Alignment of Teacher Education/Teacher/Student Standards

Key players in implementing change:
- New Superintendent
- Legislature
- State Board of Education
- Higher education institutions
- Key business leaders
- Professional Standards Council
- Delaware State Teachers Association
- Delaware Association of School Administrators
- District Superintendents and Principals

State goals for improving science teacher preparation:
- Aligning standards for teacher preparation with teacher/student/learned societies standards
- Precipitate change in science instruction for teacher education majors
- Develop a solid NCATE partnership
- Involve higher education in development of teaching standards
- Develop greater collaboration between higher education and K-12 instructors
- Improve communication and enlarge group of interested parties

To accomplish these goals, the following actions are planned:

Within six months
- Expand leadership team for science and develop plan of action, identify roles for key players
- Define NCATE partnership with involvement of higher education

During the next twelve months
- Development of teacher standards
- Review of science certification to align with Delaware Standards and national standards
- Begin to train Smithsonian project participants and itinerant teachers as mentors
- Initiation of professional development academy (Delaware State University/Col. School District)

Over the next two years
- Begin development of teacher performance assessments for beginning teachers in science (INTASC)
- Expand mentoring pilot program
- Professional development - model schools: internship/mentoring
- Revisit/revise performance appraisal system for in-service teachers
- Expand teacher program approval standards to align with Delaware teacher/student standards

By the end of five years
- Mentoring program - science content
- Retrain administrators and teachers in new performance appraisal system

Georgia's Action Plan

Team Members	Agency or Institution	Position
Robert Michaels	North Georgia College	Dean, Department of Education
Candace Norton	Georgia Professional Standards Committee	Associate Executive Secretary
Michael Padilla	University of Georgia	Director, Science Education Department

The state of Georgia team will capitalize on the existing co-reform efforts to increase statewide awareness of the *Standards*. The P-16 Initiative in Georgia is a collaborative effort of all education agencies (e.g. public K-12, private K-12) to ensure that all students are afforded maximum opportunities to achieve high academic standards through a seamless educational process.* We will work through the P-16 Council, the POET Initiative, and our professional statewide organizations (e.g. GANAEYC, GMSA) to improve teacher education in Georgia.

The Georgia Professional Standards Commission (PSC) has adopted a *Standards*-based accrediting and credentialing policy structure in lieu of a course credit hour prescription approach. In addition, the State Board of Regents (BOR) is moving from a quarter-hour to a semester-hour system, catalyzing a systemic curriculum redesign. The PSC and BOR efforts are in concert with P-16 and POET initiatives and provide a structure for a statewide systemic initiative to utilize the new *Standards*.

*One component of the P-16 initiative that is associated with our Statewide Systemic Initiative is seeking to enhance the teacher education programs of prospective mathematics and science teachers. This component, called POET (Principles of Education Teachers), honors the art of teaching and teacher preparation set is grappling with the difficulties of moving the entire state's teacher education programs to better match the *Standards*.

Illinois' Action Plan

Team Members	Agency or Institution	Position
Sunny Abello	Office of Lieutenant Governor	Assistant to Lieutenant Governor
Anna Austin	State Board of Education	Division Administrator
Robert Fisher	Illinois State University - Normal	Director, Center for Mathematics, Science, and Technology
Brenda Heffner	State Board of Education	Associate Superintendent
Michael Kurz	Illinois State University - Normal	Chair, Department of Chemistry
George Olson	Roosevelt University	Dean, College of Education
Gwendolyn Pollock	State Board of Education	Science Consultant
David Taylor	Western Illinois University	Dean, College of Education and Human Services

Illinois' Plan for Pre-service alignment to the *Standards*:

Pre-Service Project strategic planning
- Invitational meeting
- Purpose: to develop a 3-5 year strategic and tactical plan for the Review and Revision of Pre-service science and math education programs at Illinois colleges and universities
- Must consider credentialing implications

Collaboration conference(s)
- Invite deans of colleges of education and arts and sciences
- Focus on national and state science and math education initiatives including:
  National Science Education Standards and NCTM Standards
  Illinois Academic Standards Project
  Science and math state projects
- University of Illinois - Chicago/MacArthur/Joyce report on status of teacher education in Illinois
- Pre-Service Project strategic plan

Release of Request for Proposal for collaborative Pre-Service Project effort within/between colleges/universities for "Campus Renewal Grants")similarities to Louisiana and Minnesota's plans) for pilot depending on development of strategic plan

Continuation and extension of funding for pilot models through annual conferences

Indiana's Action Plan

Team Members	Agency or Institution	Position
Sandra Abell	Purdue University	Associate Professor
Kevin Beardmore	Indiana Department of Education	Science Coordinator
Michael Kobe	Hammond Public Schools	Science Coordinator

Existing policies and practices that support the *Standards*:
- Some individuals and small groups are already working in the spirit of the *Standards*. There is not sufficient space to describe these practices here.

Existing policies and practices in need of change:
- Few truly support the *Standards*, therefore we are currently overhauling our teacher preparation and certification process.

Current policies are frozen as we undertake the task of creating a performance-based system.

Key players in implementing change:
- Indiana Professional Standards Board
- Colleges and Universities
- Schools
- Indiana Department of Education

State goals for improving science teacher preparation:
- The creation of a system that is performance-based (All three members of this team are part of the Science Advisory Group that are writing Indiana's standards.)

By the end of five years
- Time will tell as performance standards take hold. Our actions by this point will also be affected by future developments at the national level.

Iowa's Action Plan

Team Members	Agency or Institution	Position
Gary Borlang	Iowa Department of Education	Licensure Consultant
Marcus Haack	Iowa Department of Education	Chief, Instructional Services
Tony Heiting	Iowa Department of Education	State Science Consultant
Greg Stefanich	University of Northern Iowa	Professor, Curriculum and Instruction
Robert Yager	University of Iowa	Professor, Science Education

Existing policies and practices that support the *Standards*:
- Modeling Reform Initiative
- Iowa Renaissance Proposal for Licensure - Induction program
- Scope, Sequence and Coordination National Test Site
- State Collaborative on Assessment and Student Standards (SCASS)
- Science, Technology, and Society (STS)

Existing policies and practices in need of change:
- Reexamination of broader endorsement areas
- Reexamination of methods to bring 31 teacher preparatory institutions up to speed on the *Standards*
- Focus on consensus
- Integrated endorsement with combined subject fields (i.e. science and math)

Key players in implementing change:
- Department of Education - Licensure-Certification-Teacher Preparation
- College Content personnel
- College Teacher Preparatory
- Department of Education - Curriculum Personnel
- Association of Independent Colleges
- Regent Institutions
- Business leaders
- Governor and legislature
- Board of Regents
- Iowa Science and Teachers Section (ISTS)
- Iowa Mathematics and Science Consortium (IMSC)
- Parents
- Associations and school boards
- Results of reform efforts (researchers)

State goals for improving science teacher preparation:
- 'Model(s)' for teacher preparation in science
- New assessment practices/evidence for success
- Review of Certification Standards
- Ties to Association of Education of Teachers of Science (AETS)
- Facility and collaboration

To accomplish these goals, the following actions are planned:

Within six months
- A meeting with representatives from teacher preparation institutions
- Become familiar with *National Science Education Standards* and Math Standards
- Respond to licensure; document on changes in certification and licensing
- Review materials from conference presenter (e.g. look at Minnesota's efforts to achieve collaboration)
- Department of Education Task Force on science reform

During the next twelve months
- Develop one to six "experiments" to collect evidence
- Set up 5 year mentoring program for improving induction of new teachers
- Preparation of system-collaborative NSF proposal

Over the next two years
- Establish a dozen professional development schools - collaboration among school districts, area education agencies, the Department of Education, universities, and interested industries
- Implement a distance learning shared supervision model between the 21 institutions in Iowa preparing science teachers

By the end of five years
- Evidence from experiments undertaken
- Have a fully implemented collaborative program between the Department of Education, institutions of higher education, Professional Development School Internship Program, and AEA Education Services

Kansas' Action Plan

Team Members	Agency or Institution	Position
DeWayne Backhus	Emporia State University	Chair, Division of Physical Sciences
Ken Bungert	State Board of Education	Director, Certification and Teacher Education
Dorothy Hanna	Kansas Wesleyan College	Associate Professor, Chemistry
Greg Schell	State Board of Education	Science Education Program Consultant
John Staver	Kansas State University	Director, Center for Science Education

Existing policies and practices that support the *Standards*:
- Kansas Science Curricular Standards
- Performance-based assessments, grades 5, 8, 10
- Outcome accreditation for schools

Key players in implementing change:
- Kansas State Board of Education
- Universities and private colleges

State goals for improving science teacher preparation:
- Committees have met and recommendations have been made to revamp licensure process

To accomplish these goals, the following actions are planned:

Within six months

- Initiate discussions with colleges and universities
- Hearing on licensure changes planned for February

During the next twelve months

- Ongoing discussions in both areas

Kentucky's Action Plan

Team Members	Agency or Institution	Position
Gary Boggess	Murray State University	Dean, College of Arts and Sciences
Joanne Lang	Kentucky Science and Technology Council	Director, Kentucky SSI
Betty Lindsey	Kentucky Department of Education	Associate Commissioner, Teacher Education
Kevin Stinson	Kentucky Department of Education	Science Consultant

Existing policies and practices that support the *Standards*:

- *Standards* are used to identify the science content tested on our state mandated high stakes K-12 assessment (open-response, performance tasks, pilot portfolios)
- *Standards* are used in the development of our new teacher certification assessments
- *Standards* drafts were featured in PRISM teacher training
- State science teacher association supports and disseminates information
- Federal program resources people at the state level require reflection of *Standards* in school transformation plans before funds can be accessed

Existing policies and practices in need of change:

- Pre-service science instruction should be *Standards*-based
- Institutions should demonstrate commitment to supporting *Standards*-based, inquiry-driven undergraduate curricula
- Integrate needed changes across campus, not just in colleges of education

Key players in implementing change:

- Kentucky Department of Education
- Business community
- Colleges of education (public and private)
- Colleges of arts and sciences (public and private)
- Deans, presidents of colleges and universities
- Teachers
- KTIP supervising teachers
- PRISM
- Professional Standards Board
- Kentucky Education Association
- Legislators
- Administrator organizations
- Association of Independent Colleges
- Pritchard Committee
- Partnership for School Reform
- Math and science teacher association

State goals for improving science teacher preparation:

- Change role for teacher from source to catalyst
- Integration of content and methodology
- Operationalize the link between certification and accreditation in a coherent way that is based on authentic standards that reflect needs of Kentucky students and schools
- Implement individual and organizational accountability for accomplishment under improved system

To accomplish these goals, the following actions are planned:

Within six months

- Participate in planning of statewide math/science summit. Planning includes identifying purpose/products of summit, key players to involve, etc.
- Participate in PRISM undergraduate conclave (forum for sharing promising practices, etc.)

During the next twelve months

- Statewide math/science summit

Over the next two years

- New teacher certification program takes effect (assumes key players have engaged in ongoing dialogue)

Louisiana's Action Plan

Team Members	Agency or Institution	Position
Nelwyn Chenevert	Louisiana Department of Education, Bureau of Higher Education	Assistant Director
Kerry Davidson	Board of Regents	Senior Commissioner
William Deese	Louisiana Technical University	Professor
Diane Garbo	Louisiana Department of Education, Bureau of Higher Education	Assistant Director
Robert Greg Hussey	Louisiana State University	Professor, Physics
Paul A. Long	Louisiana Department of Education	Program Manager, Science and Environment Education
Celeste Pea	Louisiana State Systemic Initiative	
Linda Ramsey	Louisiana Technical University	Coordinator and Instructor, Science Education
William A. Rieck	University of Southwestern Louisiana	Professor, Education
Carolyn Talton	Louisiana Technical University	Director, Student Teaching

Existing policies and practices that support the *Standards*:

- Louisiana Systemic Initiatives Program (LaSIP)
- Louisiana Collaborative for Excellence in Preparation of Teachers of Mathematics and Science (LaCEPT)
- Louisiana Networking Infrastructure for Education (LaNIE)
- Eisenhower funds
- Louisiana Education Quality Support Fund (LEQSF)
- Challenge Grants
- NSF-funded programs
- Department of Education
- NASA EPSCOR Project
- Department of Energy Wetlands Center Project
- LEARN 2000
- Louisiana Science Framework draft
- URI, Urban Systemic Initiative, New Orleans

Existing policies and practices in need of change:

- Teacher certification policies need to be reviewed
- Models illustrating reform-based teaching and assessment strategies
- Professional development practices need to be reevaluated for middle school
- Science Framework needs to be brought forward for adoption in 1997
- LEA's need to acquire funds for the new textbook adoption program
- Funding policies need to become more flexible for materials of instruction

Key players in implementing change:
- Louisiana Science Teachers Association President - Jean May-Brett
- Louisiana Science Supervisor Organization President - Ray Poplus
- Board of Regents
- Board of Elementary and Secondary Education (BESE)
- Louisiana AAPT Chapter
- Louisiana Earth Science Teachers Association
- Louisiana Academy of Sciences
- Louisiana Science Leadership Institute Network Center, La SciLINC
- American Chemical Society
- University administration

State goals for improving science teacher preparation:
- Follow NSTA Guidelines for teacher preparation in science
- Implement successful LaCEPT model programs
- Follow NSF Guidelines for *Standards*-based model instruction programs

To accomplish these goals, the following actions are planned:

Within six months
- Louisiana Department of Education Academic Program to meet with Teacher Certification Department to begin dialogue and HEA's
- Begin collecting data to validate and evaluate success of pilot programs
- Begin review of professional development programs at all levels
- Board of Regents to consider policy, procedures, and programs

During the next twelve months
- Identify areas of change and meet jointly with HEA's teacher training group
- Provide necessary waivers for school systems adopting integrated programs at middle and high school
- Begin to revise models for professional development
- LaSIP, the Louisiana Department of Education, and LEA will develop consolidated plans which when they intersect will reinforce the *Standards*

Over the next two years
- Complete teacher certification changes
- Monitor and adjust professional development programs
- Provide additional help to small systems

By the end of five years
- Continue to monitor, evaluate, and validate professional development models

Maine's Action Plan

Team Members	Agency or Institution	Position
Peter Corcoran	Bates College	Associate Professor, Education
Thomas Keller	Maine Department of Education	Science Education Specialist
Judith Malcolm	Maine Department of Education	Director, Higher Education
Shirley Oliver	Maine Department of Education	Chair, Teacher Certification Committee
Jill Rosenblum	Maine Mathematics and Science Alliance	Assessment Specialist

Existing policies and practices that support the *Standards*:
- Maine's Learning Results
- Maine's Curriculum Framework in Math and Science

Existing policies and practices in need of change:
- Entire issue is being examined. Move from an input driven system ("correct" courses, number of courses) to a results-based initial teacher certification system.

Key players in implementing change:
- State Board and its Task Force and subcommittees looking at the new system
- Legislature's Education Committee
- Maine Educator's Association
- Maine Department of Education
- Higher education institutions

State goals for improving science teacher preparation:
- To produce teachers who demonstrate the knowledge and skills necessary to effectively teach science

To accomplish these goals, the following actions are planned:
- Implement results-based initial certification
- Develop and implement results-based certification renewal

  Within six months
  - Work with higher education pilot sites who are piloting new results-based standards, targeting math and science
  - Present to the Task Force on Results-Based Initial Teacher Certification - recommend beginning process of developing performance standards with science
  - Present to the state board on Maine's Curriculum Framework in Math and Science and its implications for certification
  - Offer support/resources of MMSA (MESSI) in the effort

  During the next twelve months
  - Present the Curriculum Framework to Beacon College (a virtual college composed of faculty from education and arts and science colleges in Maine)
  - Monitor/be involved in legislation prepared by the state board concerning new certification modes
  - Support that legislation

  Over the next two years
  - Investigate the following:
  - Mentoring/support for new teachers
  - Continuous, ongoing professional development strategy
  - Developing common, coherent, standards-based goals for all of the state's certifying institutions

Maryland's Action Plan

Team Members	Agency or Institution	Position
Lawrence Boucher	Towson State University	Dean, College of Natural and Mathematical Sciences
Eileen Bowers	Maryland Department of Education	Program Approval Specialist
Diane Householder	Maryland Department of Education	Specialist in Science
John Layman	University of Maryland - College Park	Professor, Physics and Science Education
Lawrence Leak	Towson State University	Associate Professor, Secondary Education
Virginia Pilato	Maryland Department of Education	Chief, Teacher of Education
Robert Ridky	University of Maryland	Professor

Existing policies and practices that support the *Standards*:

- Current state regulations regarding Program Approval provide for "standards that are performance-based, reflect contemporary thinking, and are supported by research, best practice, and expert opinion." These may include the standards of ". . . the Interstate New Teacher Assessment and Support Consortium (INTASC) or standards developed and validated by other national organization or by the Maryland State Department of Education."
- Current state regulations regarding teacher certification through transcript analysis require:
  a. Early Childhood Education: 12 semester hours in science
  b. Elementary Education: 12 semester hours in science
  c. Biology: degree with biology major or 36 semester hours of biology content
  d. Chemistry: degree with chemistry major or 36 semester hours of chemistry content
  e. Earth/space: degree with earth/space major or 46 semester hours of earth/space content
  f. Physical science: degree with physical science major or 36 semester hours of physical science content
  g. Physics: degree with physics major or 36 semester hours of physics content
- The current Maryland School Performance Assessment Program measures how well schools are teaching students the knowledge and skills they need to solve real-life problems. In science, students are asked to ". . . demonstrate ways of thinking and acting inherent in the practice of science."
  a. Performance-based science assessments are currently given in grades three, five, and eight
  b. Performance-based science assessments will be implemented for high school students. To receive a high school diploma, students will be required to demonstrate proficiency in the Core Learning Goals

Existing policies and practices in need of change:

- Teacher education programs may be aligned with the *Standards* as they move through the five-year program approval cycle
- Local school systems will be encouraged to increase continuing professional development science experiences for use in staff Professional Development Plans. This is especially critical for early childhood and elementary education teachers. Secondary science educators must be alert to current changes and take necessary steps to remain on the cutting edge of best practice
- Maryland State Department of Education Certification Branch may explore the possible need for higher standards in science content courses for early childhood elementary education candidates seeking certification via transcript analysis. If necessary, initiate regulation changes
- Improve student learning K-16 through a K-16 Partnership. Attention will need to be focused on science learning in this new partnership

Key players in implementing change:

- Maryland State Department of Education
  a. Division of Instruction
  b. Division of Certification and Accreditation
  c. Division of Planning, Results, and Information Management
  d. Office for School Improvement
- Institutions of Higher Education - Deans and Directors of Teacher Education
- Major Funded Projects - Project Leaders
- Local School Systems - Directors of Human Resources and Personnel Specialists, Staff Development Specialists and Science Supervisors

State goals for improving science teacher preparation:
Continuing of the Schools for Success initiative begun in April 1990, which established 10 major goals to be met by the year 2000

A. The *Standards* will help Maryland to meet these four goals:
   1. Maryland will rank in the top five state in the nation on national and international comparisons of student achievement and other measures of student success
   2. 95% of Maryland's students will achieve satisfactory levels in mathematics, science, reading, social studies, and writing/language arts on state-developed measures
   3. 50% of Maryland's students will achieve excellence levels in mathematics, science, reading, social studies, and writing/language arts on state-developed measures
   4. The number of Maryland students pursuing post-secondary studies in mathematics, science, and technology will increase by 50%

B. Implementation Procedures:
   1. Increase the number of science courses required for elementary and middle school teachers. Examine model programs and recommend base-line requirements
   2. Include physical science, earth science, and biology in course requirements for all teachers. Examine model programs and recommend base-line requirements
   3. Provide science content courses that model the recommendations of the *Standards* for instructional techniques classroom teachers will be expected to use
   4. Provide appropriate technology training for all science teachers (use of graphing calculators, CBL, Internet access, etc.)
   5. Provide summer intern experiences with scientific research facilities, e.g., Martin Marietta Graduate Fellows Program for the Governor's Academy graduates which is organized by the University of Maryland - Baltimore County
   6. Include updated laboratory and storage safety techniques, appropriate use and care of living organisms, performance assessment strategies, etc. in course work. This may be accomplished through Maryland approved continuing professional development experiences

As teacher education programs are brought "on line" with the *Standards*, the impact upon learning the local classroom will be felt and demonstrated through our annual Maryland School Performance Report. This completes the K-16 reform effort

To accomplish these goals, the following actions are planned:

Within six months

1. Communication, continued widespread dissemination
   - Science Core Learning Goals modified to reflect the *Standards* to all teachers in the state. Teachers must "buy into" for success
   - Other stakeholders, including:
     Abell Foundation
     Greater Baltimore Committee
     Maryland Business Roundtable
     Local School Systems, including Continuing Professional Development Liaisons
     Institution of Higher Education—Deans and Directors of Teacher Education
     University of Maryland System—Chancellor's Commission on Science/Math
     Baltimore Urban Systemic Initiative
     Quality Education for Minorities
2. Endorsements, including:
   - Maryland State Teachers Association
   - Baltimore Teachers Association
   - PTAs
3. Establish a plan with a timeline and benchmarks for the monitoring of progress
4. Identify state coordinators, one in Division of Instruction and one in Program Approval (Maryland State Department of Education)

During the next twelve months

1. Examine:
   - Congruence between the *Standards* and Maryland reform efforts (science outcomes for K-8 and the High School Core Learning Goals)
     a. How do the Maryland reform efforts support the Science Content Standards?
     b. How can the Maryland reform documents encourage the development of the Education Program Standards?
     c. How do these documents provide the connection between MSPAP and the Assessment Standards?
   - Coherence with state review process
     a. Maryland Higher Education Commission - program review
     b. Maryland State Department of Education - program approval
     c. Maryland State Department of Education/NCATE Partnership - program review
   - Survey institutions of higher education to find out how actively they are currently engaged with the *Standards* currently
2. Make recommendations for action or modification to appropriate stakeholders as a result of the above examinations
3. Create state-approved continuing professional development workshops and other learning opportunities for teachers' professional development with credit that counts toward recertification

Over the next two years

1. Reform - wed standards (content) to curriculum at state and local level
2. Support State Staff Development Programs
   - Training focused on an understanding of the High School Core Learning Goals for Science and the Science Outcomes for grades K-8
   - Training designed to develop teacher proficiency in the scoring of the science assessments

Training for the development of lessons based on the guidelines and vision of the *Standards* and the Maryland documents (High School Core Learning Goals in Science and the Learning Outcomes for Science)

By the end of five years or 2004

1. Examine progress—has the state achieved the goals set forth in Schools for Success?

Massachusetts' Action Plan

Team Members	Agency or Institution	Position
Bob Barkman	Springfield College	Professor, Science and Education
Leslie Blatt	Clark University	Professor, Physics and Education
Anita Greenwood	University of Massachusetts - Lowell	Assistant Professor, Science Education
Lynette Robinson-Weening	Higher Education Coordinating Council	Senior Associate for Policy Development
Mary Ann Simensen	Massachusetts Department of Education	Education Coordinator, Staff Development

Existing policies and practices that support the *Standards*:

- Existing Frameworks based on draft NRC recommendations
- Blueprint for Teacher Preparation in Mathematics and Science in draft form
- Commitment from Department of Education to align regulations to Frameworks and other education reform issues

Existing policies and practices in need of change:
- Twenty-four credit interdisciplinary model
- Align licensure with Frameworks
- Portfolio assessment system for movement from provisional to standard
- Enforcement consistency for program and individual route to certification
- Ambiguity of eligible majors should be cleared up
- Supervisors of student teachers should be in the same content area
- Generalist certificates need specific electives to ensure needed content and pedagogy
- Continuing discussion of need for breadth in science preparation at the middle and high school levels.

Key players in implementing change:
- Department of Education Standards Cluster
- Legislature
- Governor and Chair of Board of Education
- Presidents and Deans of preparatory institutions
- Superintendents, principals, and teachers

State goals for improving science teacher preparation:
- Coherent multi-stage system in place which links all education reform to college and university program approval
- Middle school certification move toward integrated model different from high school

To accomplish these goals, the following actions are planned:

Within six months
- Blueprint to Board of Education relating to recommendations for science and math preparation of new teachers
- Request for proposals for assessment, via on-demand tests, of stages 1 (communication skills) and 2 (content) of the Education Reform Law (1993) of Massachusetts requires testing of new teachers

During the next twelve months
- Working with colleges of math and science and education deans to ensure they understand the vision for reformed teacher preparation.

Michigan's Action Plan

Team Members	Agency or Institution	Position
Theron Blakeslee	Michigan Department of Education	Science Consultant
Barbara Johnson	Michigan Department of Education	Consultant
Robert Kohrman	Central Michigan University	Associate Dean, Arts and Sciences
Dorothy Van Looy	Michigan Department of Education	Supervisor, Teacher Preparation

Existing policies and practices that support the *Standards*:
- Science Curriculum Frameworks
- Michigan State Systemic Initiative (MSSI)
- State Board Professional Development Standards
- Eisenhower Higher Education Professional Development Grants
- Michigan Education Assessment Program (MEAP)
- Mathematics and Science Centers

Existing policies and practices in need of change:
- Science endorsement too broad - needs to be redefined
- Standards for teacher education
- Coordination between and within colleges and institutions methods (inquiry, reward systems, diversity)

Key players in implementing change:
- Teachers (LEA, ISD)
- Higher Education (professors and administrators), Dean's Council
- State Department of Education: curriculum, MEAP, Eisenhower Higher Education, Teachers Certification, Michigan Science Teachers Association
- Michigan State Systemic Initiative - teacher education practices and professional development

State goals for improving science teacher preparation:
- Seek input from stakeholders to redefine endorsement requirements

Minnesota's Action Plan

Team Members	Agency or Institution	Position
Bruce Dickau	College of St. Benedict	Professor, Education Department
John Frey	Mankato State University	Professor, Biology
Katie Koch-Laveen	Apple Valley High School	Science Teacher
Frances Lawrenz	University of Minnesota	Associate Dean, Curriculum and Instruction
Judy McGilvrey	SciMath^{MN}	Licensure Specialist
Laurie Peterman	SciMath^{MN}	Science Project Manager
Patricia Simpson	St. Cloud State University	TTE Project Manager

Existing policies and practices that support the *Standards*:
- TTE Framework
- INTASC Standards
- Board of Teaching redesigned scope of practice
- Inclusion of stakeholders in licensure defining process

Existing policies and practices in need of change:
- Current licensure sunsets July 1, 1996. Re-structure licensure requirements
- Clinical experiences and supervision of student teaching need to be improved and made coherent
- Articulation needs to be improved

Key players in implementing change:
- Board of Teaching
- Legislature
- SciMathMN
- Minnesota State Teachers Association - classroom teachers
- Higher education - math, science, education, administration
- School administrators

State goals for improving science teacher preparation:
- Implementation of TTE Framework
- Continue efforts to align K-16 policy and practice with *Standards*
- Need cooperation/collaboration with school administrators around the state on the goals
- Redefining the role/job of a teacher (importance of collaboration and renewal) - more coaching/facilitator (need more public awareness of role)

To accomplish these goals, the following actions are planned:

- Must require the careful leveraging of funds for these changes

Within six months

- Continuing support of dialogue grants at teacher preparation institutions
- Rewriting all the licensure requirements (initial licensure standards)
- Major state conference to promote *Standards* involving many stakeholders
- Statewide conference of K-12 and higher education faculty focusing on TTE document
- Regional meetings focusing on transforming *Standards* to science teaching and content standards

During the next twelve months

- New round of dialogue grant proposals for institution projects
- Solicit funds from outside sources for higher education collaboration on TTE
- Continuous series of meetings for stakeholders

Over the next two years

- Institute some form of an induction year
- Satisfactory completion of the induction year based on clear standards
- Refunding of SciMathMN organization
- Add mentoring dimension to TTE
- Reevaluate TTE Mission, assess implementation

By the end of five years

- Reevaluate, recognize victories, and keep on moving forward

Mississippi's Action Plan

Team Members	Agency or Institution	Position
Johnny Franklin	Mississippi Department of Education	Director, Instructional Development
Brian S. Knippers	Mississippi Department of Education	Science Specialist

Existing policies and practices that support the *Standards*:

- Implementation of the Mississippi Science Framework
- Statewide Technology Plan
- Revision of Statewide Professional Development Program for all teachers
- Development of an "add on" endorsement requirement to teach high school physical science beyond general science certification
- Development of a Biology I subject area exam
- Continue reform through the Mississippi Technology Preparation Initiative

Existing policies and practices in need of change:

- More science content for K-4 teachers in pre-service programs (not necessarily more core university science courses)
- Continue to evaluate the effectiveness of the middle school teaching certification program
- Secondary pre-service programs unifying and connecting content, pedagogy, and assessment

Key players in implementing change:
- Mississippi Science Teachers Association
- Colleges, community colleges, and universities
- Mississippi Department of Education
- Mississippi Environmental Education Centers and Museums
- Mississippi Department of Environmental Quality
- Cooperative Extension Service
- Mississippi Biology Teachers Association
- Legislature and government offices
- Mississippi Forestry Commission, Soil and Water Conservation, and Wildlife Departments
- Mississippi Staff Development Council
- Federal agencies within Mississippi
- NSF, US Department of Education, SERVE Regional Laboratory programs in Mississippi
- Mississippi foundations
- Mississippi Educational Television (MSETV)
- NASA, CS3, and CCSSO
- Air Force, Naval Oceanographic Command, Army Corp. of Engineers

State goals for improving science teacher preparation:
- Multiple strategies for statewide professional development using pre-service and practicing teachers
- Establish open lines of communication among teachers, professors, and policy makers

To accomplish these goals, the following actions are planned:

Within six months
- Communicate the *Standards* to all players
- Incorporate the *Standards* in the summer of 1996 at Mississippi Science Framework training

During the next twelve months
- Through MSETV and a grant from SERC (Satellite Education Resource Consortium) conduct for training telecasts on the *Standards*
- Implement the Biology I Assessment
- Implement the physical science "add on" endorsement including a special summer training institute in 1996 and 1997

Over the next two years
- Evaluate the effectiveness and implementation of the *Standards* and the Mississippi Science Framework
- Continue to coordinate, offer, and seek funding for ongoing professional development

By the end of five years
- Begin the revision process of the Mississippi Science Framework
- Evaluate and revise all teacher preparation programs involving science
- Involve actively all partners in the continuing preparation and professional development of science teachers

Missouri's Action Plan

Team Members	Agency or Institution	Position
Cindy Heider	Department of Elementary Education	Director, Professional Development
Michael Horvath	Missouri Southern State College	Dean, School of Education and Psychology
C.J. Varnon	Department of Elementary and Secondary Education	Science Consultant

Existing policies and practices that support the *Standards*:
- Missouri "Show-Me" Standards aligned to *National Science Education Standards* (These are process and content standards)
- One percent of state education dollars are allocated for K-12 professional development
- Missouri has a Unified Science Degree for grades 9-12
- Missouri Science Curriculum Frameworks are based on the *Standards*
- State assessment system has a performance-based component
- Statewide science symposia and conference

Existing policies and practices in need of change:
- Too many certificates available (over 240)
- Streamline licensure mechanism
- Certification based on list of courses instead of competency
- Elementary teachers need more science content before licensure
- Prospective teachers need to experience multiple learning/teaching strategies in their own learning environment
- Teachers need more control of entry/exit of their colleagues
- One or two-year internship needed before certification

Key players in implementing change:
- Teacher education colleges and universities
- State agencies
- State teacher organizations
- Local professional development committees
- State legislatures
- Governor
- Business community

State goals for improving science teacher preparation:
- Align Missouri Teacher Preparation guidelines with national guidelines
- Enter into a closer working relationship with NCATE
- Support NBPTS
- Make teaching more attractive by continuing to professionalize

To accomplish these goals, the following actions are planned:

Within six months
- Apply for a systemic reform grant (*Standards*-based instruction and assessment) from the Missouri Department of Elementary and Secondary Education
- Hold training sessions at Missouri's nine regional Professional Development Center for pre-service/in-service teachers
- Showcase best practices in science education and science teacher preparation programs
- Collaborate with Missouri Association for Colleges of Teacher Education to raise awareness level in and about the *Standards*

Within six months
- Move from awareness level to application level in best practices
- In-service content area professors on inquiry-based instruction
- Integrate Missouri "Show-Me" Standards into pre-service and in-service teacher preparation programs

During the next twelve months
- Expand program to all 35 teacher education colleges and universities
- Ongoing awareness and content training form the first six-month program

Over the next two years
- At least one-half of K-12 teachers will be using inquiry-based instruction in science

New York's Action Plan

Team Members	Agency or Institution	Position
Betsy Ann Balzano	SUNY Brockport	Professor
Carolyn Graham	Troy City Schools	Curriculum Coordinator
Penelope Haile	Hofstra University	Associate Dean, School of Education
Janice Koch	Hofstra University	AssociateProfessor
Jim Neujahr	City College of New York	Professor
Linda Stehr Bopp	New York Department of Education	MST Curriculum Framework Coordinator

Existing policies and practices that support the *Standards*:
- State testing program in Science - 4th grade, Regents
- State teacher certification requirements - LAST, content exams in subject area
- Compact for learning
- Teacher certification requirements—coursework required
- Curriculum Frameworks for Mathematics, Science and Technology with Learning Standards.
- BOCES 2 Elementary Science Program (materials, workshops, etc.)
- Move to portfolio in assessment
- SSI, USI, CETP programs to support teacher development, teacher education program development and teaching which are congruent with the *Standards*

Existing policies and practices in need of change:
- Funding, staffing level
- Improve system of checking off courses only as route to certification
- Improve continuous, professional development over time (i.e. permanent certification - often discourages this)
- Entry of scientist and engineers into technology education/science/math certification programs
- Lack of correspondence between, collaboration with, and alignment of teacher education and academic science departments
- Multiplicity of teacher certification titles
- Number of waivers permitting teachers to teach science without appropriate certification
- Paucity of partnerships with business and industry
- Lack of alignment of certification with Curriculum Frameworks and Learning Standards outcomes

Key players in implementing change:

- State Education Department
- NYSUT/NEA
- Science Mentor Network
- SCDN
- NYS Administrator Association
- SUNY
- CUNY
- STANY
- Teacher development centers
- Universities/colleges with teacher preparatory programs
- NYSTEN (mentor network)
- NYS School Boards Association
- Deans/Teacher education in NYS
- NYS Board of Regents
- NYS Legislature
- Chancellor, NYC Board of Education
- SSI Schools/Partnerships

State goals for improving science teacher preparation:

- Tie ATSP to the *Standards*
- Teacher preparation models lessons adhering to the *Standards*
- Preparation and classroom instruction K-12 tie to compact for learning and the State Framework for Mathematics, Science, and Technology
- Learning Standards for Mathematics, Science and Technology
- Consideration of performance and knowledge of content as well as pedagogy and completion of courses/programs

To accomplish these goals, the following actions are planned:

Within six months

- Print and distribute guide for teacher preparation faculty for mathematics, science and technology

During the next twelve months

- Revisit and rewrite the LAST, ATS-W and content specialty exams to reflect the *Standards*

Over the next two years

- Revisit and rewrite the LAST, ATS-W and content specialty exams to reflect *Standards*

By the end of five years

- Require the review of approved teacher education programs to determine the extent to which they align with and implement the *Standards*. (The reviews can be conducted by appropriate national associations).

North Carolina's Action Plan

Team Members	Agency or Institution	Position
Jake Brown	Department of Public Instruction	Science Consultant
Marilyn Jorden	North Carolina Science and Mathematics Alliance	Director
Gerry Madrazo	North Carolina Mathematics and Science Education Network	Executive Director
Bill Spooner	Department of Public Instruction	Director, Division of Curriculum and Instruction
Clara Wiggins	Department of Public Instruction	Science Consultant

Existing policies and practices that support the *Standards*:
- Science Teacher Education IHE's must meet the State Accreditation Guidelines which are developed under SEA leadership
- New state science curriculum which reflects the *Standards*

Existing policies and practices in need of change:
- Need revision of the NC Competencies and Guidelines for Science Teacher Preparation to reflect the *Standards* at grades 6-12 level and the elementary guidelines, science section

Key players in implementing change:
- Department of Public Instruction
- Science Team
- Program Approval/Certification Team
- State Board of Education
- Math/Science Education Network
- State SSI
- IHE
- LEA

State goals for improving science teacher preparation:
- Make *Standards* familiar to science educators and education leaders across the state
- Revise the Competencies and Guidelines for Science Teacher Preparation in North Carolina to reflect the *Standards*
- Revise the Elementary Competencies and Guidelines for Science Teacher Preparation (science portion) to reflect the *Standards*

To accomplish these goals, the following actions are planned:

Within six months
- Complete revision of the NC Competencies and Guidelines for Science Teacher Preparation to reflect the new *Standards*
- Present to the State Board of Education
- Implement upon Board adoption
- Conduct a statewide conference/forum on the *Standards* for head and key science educators in North Carolina to address successful implementation of the *Standards*

During the next twelve months
- Revise and implement the science portion of the Elementary Competencies and Guidelines for Science Teacher Preparation

Over the next two years
- Education members of state program approval teams to the *Standards*

By the end of five years
- All teacher preparation related to science in North Carolina will be directly tied to the *Standards*

North Dakota's Action Plan

Team Members	Agency or Institution	Position
Ann Clapper	Department of Public Instruction	Director, Curriculum
Allan Fischer	North Dakota State University	Dean, College of Science and Mathematics
Joe Kroeber	Legislator/Science Teacher	Representative
Max Laird	Community High School	Science Teacher
Debra Tomanek	North Dakota State University	Assistant Professor, Botany

Existing policies and practices that support the *Standards*:
- Math/Science Alliance
- Science Focus Group
- Assistance from McREL (Regional Lab)

Existing policies and practices in need of change:
- Pre-service needs application of new *Standards* throughout higher education
- Licensure is new but will need to move from awarded credits toward *Standards* orientation

Key players in implementing change:
- Math/Science Alliance
- North Dakota Science Teachers Association
- North Dakota CTM
- Science Focus Group
- Higher Education Institution
- Department of Public Instruction (DPI)
- ESPB
- EPSCOR
- NDEA
- School Boards Association
- North Dakota Association of School Administrators
- North Dakota Parent Teacher Association

State goals for improving science teacher preparation:
- Establish communication links and partnerships with key organizations
- Coordinate science improvement efforts and resources
- Provide information, training, and technical assistance on and implementation of the *Standards*
- Collect information on results of implementing the *Standards*; identify areas for training and barriers to implementation
- Make recommendation to the ESPB, NDUS, and DPI relative to changes needed in accreditation, licensure certification, and professional development

To accomplish these goals, the following actions are planned:

Within six months
- Prepare and disseminate a summary of the symposiums' proceedings along with an overview of the *Standards* to the leaders of key organizations
- Identify existing groups and organizations presently involved in science education in the state, their membership, purpose, support, and linkages to other groups
- Design a cooperative service agreement between the North Dakota State University system and the DPI outlining partnership and leadership agreements for K-16 science education
- Meet with representative from McREL to discuss training for science leaders in collaborative action research
- Present information on the symposium's proceedings and information on the *Standards* to various groups such as the ESPB, the Science Focus Group, the Dean's Council, Science Fair and Science Olympiad teachers
- Convene meeting of Math/Science Alliance to discuss issues such as status of the current science frameworks, the need for another state science symposium, status of Gateway Mail Project, and membership in INTASC
- Conduct planning meetings for summer *Standards*-awareness sessions
- Identify existing and potential sources of grant money

During the next twelve months
- Conduct awareness sessions on the *Standards*
- Discuss map of existing organizations and groups, discuss effectiveness of current configuration and create (if needed) or realign groups as needed
- Convene meeting with ESPB, the Dean's Council and other representative of the NDUS to discuss the *Standards* and potential areas of change in certification, teacher preparation, etc.
- Design graduate workshop credit (one hour) for school-site study groups around topics and themes such as collaborative action research, inquiry, portfolio assessment, constructivism, and the *Standards*
- Provide more in-depth training sessions on knowledge and skills needed to implement the *Standards*

Over the next two years
- Collect exemplary science "units" and effective strategies created and used by North Dakota teachers and place in a database for statewide access
- Create network of "best practice science teachers;" fund release time for them to assist teaching in neighboring schools
- Gather information from the field or policy barriers to implementation
- Convene meeting with ESPB, Dean's Council, and NDUS representatives to discuss barriers and make recommendations for change

Oklahoma's Action Plan

Team Members	Agency or Institution	Position
Cindy Marose	Oklahoma Department of Education	Director, Certification Standards
Mary Stewart	Oklahoma Department of Education	Science Coordinator

Existing policies and practices that support the *Standards*:
- Priority Academic Student Skills (PASS) - state framework for schools

Existing policies and practices in need of change:
- Oklahoma is in the process of developing a competency-based teacher certification system, to be completed by January 1997

Key players in implementing change:
- State Board of Education
- Institutions of high education
- Local districts (including teachers and administrators)
- Professional education organizations
- Science organizations
- Businesses that relate to science
- Oklahoma Regents for Higher Education
- Department of Vocational-Technical Education
- Oklahoma Commission for Teacher Preparation
- Recipients of Teacher Preparation grants

State goals for improving science teacher preparation:
- Certification competencies with emphasis on methodology and reference to Priority Academic Student Skills (state framework for schools)
- Fall science certification competencies
- Oklahoma has received a $5 million NSF grant for changing/reforming the math/science preparation

To accomplish these goals, the following actions are planned:

Within six months
- Input for full science competencies
- State Board adoption of general competencies

During the next twelve months
- State Board adoption of full competencies

Over the next two years
- Review PASS (include business, general public, educators, professional education organizations)
- Review state student testing program over PASS

By the end of five years
- Review, reevaluate, reflect

South Carolina's Action Plan

Team Members	Agency or Institution	Position
Dan McKenzie	Lexington School District #1	Science Coordinator
Sandy Robinson	University of South Carolina	Assistant Dean, College of Education
Linda Sinclair	South Carolina Department of Education	Education Associate - Science
Jim Turner	South Carolina Department of Education	Education Associate - Teacher Licensing

Existing policies and practices that support the *Standards*:
- Continuous, sustained staff development based on needs identified with strategic plan of local school districts
- SSI Curriculum Leadership Institutes that develop teacher leaders or mentors and Administrative Leadership Institutes that prepare administrators to support meaningful staff development
- South Carolina Science Framework supports changes in Professional Development that articulate with the *Standards*
- Proposal that South Carolina Teacher Education Programs meet National Accreditation Standards by the year 2005
- Entire Teacher Education - Licensure process is under study - task force appointed and dialogue sessions have begun
- Implementation of South Carolina system for Assisting, Developing, and Evaluating Professional Teaching (ADEPT)

Existing policies and practices in need of change:
- Policies related to initial and add-on certification need revision
- More communication/collaboration between higher education and State Department of Education
- Professional development-license renewal requirements should reflect higher standards with local district coordination
- More in-depth/long-term teacher internship or induction programs

Key players in implementing change:
- State Superintendent of Education
- Commissioner of Higher Education
- Deans of Teacher Education Colleges
- Deans of Colleges of Arts and Sciences
- Staff members of State Department of Education
- State School Boards Association
- Science Teachers Organizations—Chemistry Teachers, Physics Teachers Alliance, Environmental Education Association, South Carolina Science Supervisors, and the South Carolina Association of Children's Science
- Director of SSI and SSI HUBS

State goals for improving science teacher preparation:
- Goals are addressed in the South Carolina Science Frameworks (draft version) and "At the Crossroads" (task force document and discussion paper)
- Move to require National Accreditation of all teacher education programs

To accomplish these goals, the following actions are planned:

Within six months
- Committee report/meeting with Superintendent of Education
- Continued discussion of recommendations set forth in "At the Crossroads"
- Revised version of South Carolina Science Framework, which includes a professional development chapter, will be submitted for approval by the State Board of Education
- Begin implementation of South Carolina Science Framework

During the next twelve months
- Pilot testing of NCATE partnership
- NCATE approved institutions will provide technical assistance to other state colleges and universities
- Some state institutions will begin the process of submitting folios to NSTA for NCATE evaluation
- Continued implementation of Science Framework - Expand vision of Science Framework to higher education level
- Appointment of specific task forces to develop proposals included in "At the Crossroads"
- Promote and approve Eisenhower proposals and other grants that support the professional development vision of Science Framework

Over the next two years
- Recommendations of "At the Crossroads" Task Force presented to State Board of Education and state legislature
- Promote/approve Eisenhower proposals that support professional development vision of the South Carolina Science Framework and the *Standards*

By the end of five years
- By 1999, all state teacher education programs are progressing on schedule toward National Accreditation
- "At the Crossroads" Task Force recommendations are implemented
- Continued implementation and revision of South Carolina Science Framework

South Dakota's Action Plan

Team Members	Agency or Institution	Position
Elizabeth Bower	South Dakota Department of Education and Cultural Affairs	Director, Teacher Education and Certification
Bill Jensen	South Dakota State University	Professor, Chemistry
Janet Martin	South Dakota Department of Education and Cultural Affairs	Associate Director, Science

Existing policies and practices that support the *Standards*:
- NCATE Partnerships
- Administrative Rules of South Dakota (both present and those in proposal for revision)

Existing policies and practices in need of change:
- Administrative Rules of South Dakota
  a. Professional Studies
  b. Pre-service internships
  c. Assessment concerning content areas and pedagogy

Key players in implementing change:
- South Dakota Legislature
- DECA - Secretary, upper level supervisors, technical assistance team
- Deans of Education at liberal arts schools
- School Administrators of South Dakota
- Associated School Boards of South Dakota
- South Dakota Education Association
- Board of Regents
- State Board of Education
- Learned societies
- State professional organizations

State goals for improving science teacher preparation:
- Process for dialoguing Pre-K-16 related to implementation of the *Standards*
- Involvement with SASD, ASBSD, SDED, Regents, State Board, Legislature
- Developing accountability process for incrementalization of the *Standards* implementation plan

To accomplish these goals, the following actions are planned:

Within six months
- Gather final approval of implementation plan
- Publish plan - DECA homepage, administration memo, organization newsletters, conferences; present, plan and gather input at each organizations' meeting
- Conduct ongoing evaluation of implementation activities
- Initiate school accreditation process that is outcome-based K-12 and teacher education

During the next twelve months
- Meet with content area professors and deans together with K-12 subject area teachers, administrators, and school boards in work sessions to plan in-depth implementation activities - localizing efforts
- Initiate formal assessment of impact of the *Standards*
- Pilot accreditation process - K-12 and teacher education

Over the next two years
- Keep formative evaluation on implementation plans
- Plan facilitation activities where faltering is detected
- Continue evaluation of implementation activities
- Implement accreditation process . . . with a process for noting needs and providing support

By the end of five years
- Analysis of assessments and initiate plan for enhancement of programming due to *Standards* changes and/or detection of needs

Tennessee's Action Plan

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Karen Weeks	State Board of Education	Research Associate

Existing policies and practices that support the *Standards*:
- State curriculum framework K-12 (adopted 12/95) - consistent with *Standards*
- Teacher Education Policy (1988) - based on knowledge and skills; clinical learning; collaboration between K-12 and institutions of higher education, collaboration between teacher education and arts and sciences

Existing policies and practices in need of change:
- Need to update knowledge and skills to address more effectively the *Standards* and new state curriculum framework

Key players in implementing change:
- State Board of Education
- State Department of Education
- 39 teacher preparation institutions of higher education
- Teacher Education Advisory Council

State goals for improving science teacher preparation:
- Integration of *Standards* into knowledge and skills
- Revise professional education core knowledge and skills to conform to INTASC

To accomplish these goals, the following actions are planned:

Within six months
- Convene a working group to adjust knowledge and skills for teacher discourse
- Begin professional development for existing teachers on the Tennessee and the *Standards* in conjunction with Appalachian Educational Lab

During the next twelve months
- Bring changes in licensure standards to State Board of Education for approval

Over the next two years
- Adjust our student assessment system to conform to *Standards*

By the end of five years
- Celebrate science literacy!

U.S. Virgin Islands' Action Plan

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Existing policies and practices that support the *Standards*:
- Promotional Policy
- Virgin Islands Teacher Enhancement in Math and Science (VITEMS)
- National Faculty Program
- Goals 2000 Program

Existing policies and practices in need of change:
- Teacher certification policy
- Teacher education program

Key players in implementing change:
- Science education professors
- Science professors
- Local industries
- Elementary and secondary education teachers
- School administrators and central office administrators

State goals for improving science teacher preparation:
- Integration of new *Standards*
- Planning systemic changes in MST
- Share vision and establish collaborative relationships with the University of the Virgin Islands

To accomplish these goals, the following actions are planned:

Within six months
- Immediate planning and sharing of the *Standards* with principals and directors
- Summer science institute for teachers
- Symposium K-16/MST collaboration
- Develop a new territorial technology plan

During the next twelve months
- Implement a comprehensive effort through professional development and educational networking to enhance science and math

Over the next two years
- Complete the development of math and science framework
- Develop teacher education of math and science framework

By the end of five years
- Implement territorial systemic math and science changes
- Integrate technology into all classrooms

Utah's Action Plan

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Brett Moulding	State Office of Education	State Science Specialist
Richard Tolman	Brigham Young University	Chair, Department of Zoology

Existing policies and practices that support the *Standards*:
- State Science Core Curriculum
- Accreditation process
- Assessment practices
- Coordinated professional development program
- Statewide science coordination
- Teacher certification policies
- Science home page

Existing policies and practices in need of change:
- Recertification needs to be reinstituted
- *Standards*-based teacher preparation
- Student teaching practices

Key players in implementing change:
- State - Legislature, Governor, State School Board, Board of Regents
- Universities - University of Utah, Brigham Young University, Utah State University, Southern Utah University, Weber State University, and junior colleges
- Education coordination team, Utah Science Teacher Association, Center for Science (WSU, integrated University of Utah), service regions
- Partnerships with business and industry
- Utah Education Association

State goals for improving Utah Science Teachers Association preparation:
- Develop content courses to provide inquiry lab activities
- Add "assessment in science skills" to teacher preparation program
- Provide support system for first and second year teachers
- Require recertification requirements through demonstrated proficiency and coursework
- Move to *Standards*-based science methods courses
- Integrate pre-service teachers in existing in-service programs

To accomplish these goals, the following actions are planned:

Within six months
- Provide training on *Standards*
- Conduct a "Teacher Pre-service Preparation" conference strategic plan
- Establish a demonstration project for first and second year teachers in-service
- Develop professional development expectations

During the next twelve months
- Develop recertification policy
- Require basic certificate to include specific courses for development of standard certificate
- Revise professional development programs SSCT subcommittee

Over the next two years
- Implement "new" professional development standards (*Standards*-based)
- Establish teacher support beyond graduation

By the end of five years
- Recertification program revision
- Implementation of the *Standards* requirements in all programs

Washington's Action Plan

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George "Pinky" Nelson	University of Washington	Vice Provost
Roger Olstad	University of Washington	Professor, Science Education
Harry Peterson	State Board of Education	Member
Scott Stowell	Spokane School District #81	Curriculum Director

Existing policies and practices that support the *Standards*:
- 1993 Education Reform Legislation (performance-based education system by 2000)
- Essential academic learning requirements (content standards for science)
- State assessment training
- Refocus professional development

Existing policies and practices in need of change:
- New performance-based certification system by 2000
- Setting priorities for continuing education

Key players in implementing change:
- Superintendent for Public Instruction
- State Board of Education
- Commission on Student Learning
- Legislature
- Higher Education
- Washington Education Association
- Washington Association of School Principals
- Washington Association of School Administrators
- Washington Roundtable
- Partnership of Learning

State goals for improving science teacher preparation:
- To develop, field test, and implement new performance-based certification system tied to positive impact on student learning by 2000

To accomplish these goals, the following actions are planned:

Within six months
- Develop standards

Over the next two years
- Field test

By the end of five years
- Complete implementation

Wisconsin's Action Plan

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Laurie Derse	Department of Public Instruction	Licensing Consultant

Existing policies and practices that support the *Standards*:
- K-12 curriculum plan with graduation requirements that include the four broad areas of science (biology, chemistry, physics, and earth/space science)
- Licensing in four areas plus restrictive broad field science license which requires 15 semester credits in each area to teach at 10-12 grade level
- Required certifiable minor for all elementary education majors (30 credit science minor option

Existing policies and practices in need of change:
- Course/credit driven licensing/discipline driving science certification
- "Input-based" program approval structure (i.e. science program shall include the study of . . . rather than outcome-based)

Key players in implementing change:
- Parents/general public
- Teachers
- LEAs/Administration/Boards
- State departments
- University/colleges
- Legislature/Governor
- Professional Educational/Business/Scientific Organizations

State goals for improving science teacher preparation:

- Complete process of restructuring teacher education and licensing and continue process to develop and adopt pre-service performance standards in each of the content areas (use *National Science Education Standards* as guide for development of pre-service standards)
- Support IHE efforts between education and science departments to restructure and collaborate

To accomplish these goals, the following actions are planned:

Within six months

- Complete public information sessions on proposed recommendations for restructuring. Based on results of public input - develop proposed rule changes

During the next twelve months

- Continue through rule making process public and legislative hearings - resulting in rule promulgation
- Establish broad based groups to develop proposed pre-service content standards
- Promote/encourage IHE restructuring efforts

Over the next two years

- Adopt/implement major restructuring recommendations of
- Wisconsin "molded" INTASC standards
- Performance-based teacher education
- Career long professional development and licensing
- Revision of licensing categories and grade levels

By the end of five years

- With public and legislative support, first teachers of restructured teacher education programs will graduate and receive their beginning level license

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