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Survey of Changes in Science Teacher Preparation Programs Responding to Performance-Based Science Standards

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Abstract

This study presents the results of two web-based surveys of 23 science teacher preparation programs having functional standards-based candidate performance assessment systems recognized by the National Science Teachers Association (NSTA) through the National Council for the Accreditation of Teacher Education (NCATE). Our goal was to determine the degree and nature of changes made to these programs as they sought to gain NSTA-NCATE program recognition. The results indicate that most programs made major changes as they implemented performance assessment systems, now pay more attention to documenting candidate performances in all areas of concern covered by the standards, and believe the changes will benefit new teachers.

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Introduction

Many of the current reforms in teacher preparation began with the publication of *A Nation at Risk* (National Commission on Excellence in Education, 1983), which called for systematic reform of teacher education based on high professional standards. Since 1987, the National Science Teachers Association (NSTA), as a constituent member of the National Council for the Accreditation of Teacher Education (NCATE), has reviewed programs leading to initial licensure of science teachers for institutions seeking NCATE accreditation. Under the NCATE system, programs found to meet the NSTA Standards for Science Teacher Preparation are nationally recognized as part of the overall unit accreditation provided by NCATE.

The NSTA standards used from 1987 to 1998 were based on program characteristics such as credit hours of science, presence of a science methods course, and

so forth. NSTA paid no attention to, and did not require, indicators of actual candidate preparation and ability, such as data on their effectiveness with students.

At about the same time and NSTA began reviewing programs in the late 1980's, the science education community was developing national professional standards for what pre-college students should know and be able to do in science. The most influential of these efforts was Project 2061, which yielded *Science for All Americans* (AAAS, 1989) and the later *Benchmarks for Science Literacy* (AAAS, 1993). These documents strongly influenced the recommendations later found in the *National Science Education Standards* (National Research Council, 1996).

By providing, for the first time, a relatively consistent national definition of the goals of science education, *Benchmarks* and the *National Science Education Standards* strongly influence state standards for science education. In 1998, the National Science Teachers Association revised the *Standards for Science Teacher Preparation* (1998) in response to these changes, creating the *Standards for Science Teacher Preparation* abbreviated in the appendix.

The revised standards placed more emphasis on the assessment of candidate performance as a basis for NSTA program recognition decisions and the alignment of the standards for pre-service teacher preparation with K-12 standards for what children should know and be able to do. These changes were consistent with NCATE's strong emphasis on performance as described by Wise and Leibbrand (2001).

NSTA completed its revision of the standards in summer 1998, and the NCATE Specialty Areas Standards Board accepted them in October 1998. In 1999, institutions seeking national recognition through NCATE began writing to these new standards. NSTA was one of the first specialty associations to require teacher preparation programs to show that they make decisions on their teaching candidates through systematic performance assessments. The major elements of such a system, as described by Wise and Leibbrand (2001), include:

- A stable system of program-level candidate performances assessments clearly linked to specialty performance standards and their dimensions;
- Measures of positive candidate impacts on students for certain standards, where such performance is clearly the best and only accurate way to determine success;
- Clear candidate performance measures and criteria or rubrics with minimum proficiency levels;
- Policies and procedures at the program level for gathering, using, storing, and reporting candidate results; and
- A process whereby programs regularly review summary data from candidate assessments for program evaluation and improvement.

These requirements were a substantial change from practices in most institutions. Almost none of the approximately 80 institutions NSTA reviewed each year had program-level performance assessment systems that would systematically validate candidate performances in relation to the science standards. Consequently, NSTA

recognized few institutions during the first three years the standards were in use. Recognized programs usually had to make significant changes in their practices.

Over the past several years, a shift has occurred and an increasing number of institutions are receiving positive reviews, but the actual changes programs make in order to meet the standards are often difficult to determine from review documents because programs often do not identify them as such. Our purpose in conducting this research was to collect information from recognized programs that would give us an estimate of the degree and nature of the changes they have made to meet NSTA performance-based standards.

The questions we were seeking to answer included these:

- What degree of change has occurred in relation to each of the specific science standards?
- What nonspecific changes have occurred in programs because of their move to performance assessment?
- Have the changes helped to focus the faculty's work with candidates or the candidate's work with students; and have the changes resulted in greater use of student work to assess candidate abilities?
- Are there other notable results from the shift to a performance assessment system, and has the change been beneficial?

Methods

We obtained data from programs with candidate performance assessment systems recognized by NSTA and NCATE, using two web-based surveys conducted respectively in April and May 2003 and October 2003. Individuals identified as contacts on NCATE science program reports were invited to participate.

The first survey form consisted of five open-ended free-response questions and a series of convergent questions intended to assess change in relation to specific standards. The second survey was modified somewhat to improve the quality of our data and contained more quantitative response items; however, it retained the initial qualitative questions as well.

Our data are the qualitative responses from both surveys, and the quantitative responses from the second survey. We received 13 responses from the 21 institutions contacted for the first survey, and 10 responses from 28 institutions (including seven that did not respond to the first survey) contacted for the second survey, for an overall response rate of 55 percent.

Results

Because we are not comparing treatments or conditions, we have not employed statistical analyses in our handling and presentation of the data. We believe the meaning of the evidence we have collected is apparent on its face.

We first asked institutions to provide a quantitative rating of the degree to which their curriculum had changed in relation to each of the standards. We did not ask them to identify the nature of the change; rather, we were interested in determining whether

changes were greater in relation to some standards than to others. Our experience with reviews prior to 1999 had taught us that certain standards, such as the nature of science (standard 2, appendix) tended to be addressed less often and less well by programs than others, such as the science curriculum standard (standard 6, appendix).

Respondents based their change ratings for each standard using the criteria shown in Table 1. Table 2 presents their responses.

Table 1

Criteria used to assess change in specific standards

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4 = *Substantial changes* have been made, usually characterized by addition of one or more significant requirements such as long-term assignments, projects, or courses at the program level.

3 = *Major changes* of *existing* requirements have occurred, to better align them with the standards and ensure a certain performance outcome; or a combination of modifications and additions with major educational impact.

2 = *Minor changes* such as modifications of *existing* requirements to better align them with the standards and ensure a certain performance outcome; or a cumulatively combination of modifications and additions with minor but notable impact.

1 = *No changes* were made other than routine shifts.

0 = *Don't know* whether changes have occurred in this area.

Table 2

Results of Two On-Line Surveys Estimating Change in Relation to Individual Standards

Topic of the Standard/Assessment of candidates':	Degree of Change			
	1	2	3	4
3.1 Knowledge of subject matter/content knowledge	3	3	1	3
3.2 Knowledge/ability to apply unifying science concepts	3	2	2	3
3. Ability to design, conduct and report investigations in science	1	4	2	3
3.4 Ability to engage in problem-solving and data analysis	2	5	1	2
3.5 Knowledge of the nature of science	1	2	2	5
3.6 Ability to engage students in nature of	3	1	3	3

Topic of the Standard/Assessment of candidates':	Degree of Change			
	1	2	3	4
science studies				
3.7 Knowledge of inquiry as a teaching approach	3	1	2	4
3.8 Ability to engage students successfully in inquiry learning	2	1	5	2
3.9 Knowledge of the context of science, values, and issues	2	4	2	2
3.10 Ability to engage students in study of context/values/issues	1	4	3	2
3.11 Ability to successfully apply skills of teaching in the science classroom	2	4	1	3

Topic of the Standard/Assessment of candidates':	Degree of Change			
	1	2	3	4
3.12 Ability to plan and implement varied curricula	3	4	1	2
3.13 Ability to relate science to local and regional community	1	4	3	2
3.14 Ability to use community resources to teach science.	2	3	3	2
3.15 Ability to design/use varied/appropriate assessments	0	3	4	3
3.16 Ability to use assessments to guide and change instruction	0	3	3	4
3.17 Knowledge/ability to maintain safety	3	2	1	3

Topic of the Standard/Assessment of candidates':	Degree of Change			
	1	2	3	4
3.18 Willingness to engage in professional community	4	3	1	2
3.19 Willingness to engage in self assessment and improve performances	3	2	2	3

A considerable amount of change is apparent across all standards. Half of the institutions reported making major or substantial changes in their programs for 12 out of the 19 standards, with the strongest changes (seven or more out of the ten institutions) being made in relation to knowledge of the history and nature of science, applications of inquiry, and assessment. The least change (three or fewer reporting major or substantial change) occurred in relation to applications of mathematics, curriculum development, and engagement in professional activities—areas that are generally strong in most programs.

Our second task was to determine the kind of changes that were occurring in the programs because of the move to performance assessment. Our surveys revealed that most programs undertook major changes, including changes in the curriculum, to meet the new standards.

The qualitative responses were interesting and revealing because to their tone as well as content. One of the programs found that their context, inquiry, and nature of science standards were problematic, so they developed new strands for each of these areas. They also designed a “Literacy in the Sciences” course and had two courses in the design stages, one on the nature of science and the other on review for state exams.

Another institution added a seminar on the history and nature of science, and a third now requires a science and technology course not previously required, as well as a “Knowledge of Science” philosophy course. Several programs also reported increasing their emphasis on providing undergraduate research experiences.

Although qualitative responses were in some ways most interesting, the systematic quantitative responses in Table 3 provide a more easily digestible snapshot of change.

Table 3

Changes Made in Response to NSTA/NCATE Recommendations and Expectations (Survey 2 only, N=10)

Changes	#	%
Developed requirements for a science-specific candidate portfolio where one was not required previously	7	70
Revised previously existing candidate portfolio requirements to include new science-specific standards and expectations	4	40
Created new scoring rubrics or other criteria for existing assignments or requirements	8	80
Created new tasks and assessment instruments	7	70
Implemented a new, science-specific student teaching assessment instrument	7	70
Revised an existing student teaching assessment instrument to include new	5	50

Changes	#	%
science-specific standards		
Instituted a new science methods course	2	20
Revised an existing science methods courses to better focus on performance standards	8	80
Added new science courses requirements or modified existing requirements	4	40
Created a new data collection system to record candidate performances	7	70
Modified an existing data collection system to record candidate performances	3	30

The amount of curricular change is especially interesting because many of these institutions were reviewed and recognized under the older curriculum-based NSTA standards, which addressed similar concerns but did not require performance assessment. This seems to indicate that science standards used before 1999 were not very effective—

or at least not as effective in achieving the goal of ensuring the full preparation of candidates as the newer standards.

As expected, respondents in both surveys reported changes in the ways that they assess candidates. All of our respondents indicated that an important part of their response to performance-based standards was the development or revision of their candidate assessment instruments and procedures. New or revised instruments included student teacher evaluation forms; scoring rubrics for projects; and check sheets for portfolios that either were newly designed, or revised, to align them with the standards.

Some institutions developed new ways to collect data systematically, and one institution identified eight major changes (creating or revising assessment instruments or procedures) to their performance assessment system. Several institutions also said they had developed gateway assessment points to document student performance at specific intervals throughout their program of study.

Respondents varied in their attitudes toward the new requirements. One noted that the changes had "…quite frankly, helped us improve our service to science teacher candidates while it has placed appropriate benchmarks for them at all phases of their professional preparation." Another wrote that "state education regulations and the NCATE criteria have worked together to help us put together a more effective science education program for our teacher candidate."

Our early experiences reviewing performance-based programs revealed that many of them used only generic instruments for the supervision and assessment of student

teachers. This approach becomes less feasible when candidates are required to collect, summarize, and present student performance data to show that they are able to meet science-specific performance standards. A number of respondents indicated they had to redesign generic instruments for assessing student teachers to make them address science-specific concerns.

Methods faculty members, in particular, often had to modify at least some of their assessment expectations—most frequently to ensure the completion of key assessments. Reflecting this, one respondent reported that, "I had NEVER before specified the minimum points required to pass each assignment and the action taken if minimum points were not met. This has been incredibly successful and a very worthwhile part of the NSTA/NCATE review."

We were also interested in determining whether the changes help to focus the faculty's work with candidates or the candidate's work with students and whether they resulted in more attention to using student work to assess candidate abilities.

The answer to this question is a qualified yes. In Table 4, items one through four summarize responses from the second survey.

Table 4

*Perceptions of Significant Change for the Program as a Whole from the Second Survey (N = 10)**

Questions	Yes	No

Questions	Yes	No
1. In your experience, has the move to a standards-based performance assessment system helped you and other instructors to better define and focus on the outcomes of your candidates' activities?	7	3
2. In your opinion, has your move to a standards-based performance assessment system helped your candidates to better define and focus on expectations of the program?	7	3
3. Does it appear that instructors are more directly linking assignments, activities, and expectations in science methods courses to the NSTA or state science standards than before the implementation of the performance assessment system?	7	3
4. In the system you have created, must your candidates collect data showing that <u>their</u> students are successful and present it to a supervisor or cooperating teacher in order for their teaching performance to be considered successful?	5	5

Questions	Yes	No
5. Did the process of addressing NSTA standards and expectations provide you with any leverage with faculty or administration for making changes in your program?	6	4
6. Did the process of addressing NSTA standards and expectations result in greater interaction and/or cohesion within the program, especially between science and education faculty?	8	2
7. Overall, do you believe the changes you have made will be beneficial to your candidates, the students they teach, and the teaching profession overall?	7	1

In seven of ten cases, the respondents felt that the new assessment system provided more focus for both instructors and candidates in the program. In addition, they report better links between the standards and actions taken in the program than before the change to performance assessment.

One respondent said that the requirements "promoted science teacher candidate reflection on their prior understanding of their own performance as science teacher candidates at each phase of their education program." Another

noted that, “students are more focused now and taking their assessment very seriously.”

However, one respondent felt that self-analysis requirements just “formalized the process and created additional work for the students.” This individual further noted that, “the standards-based performance assessment system does provide a focus for the observation visits and cooperating teacher evaluation.”

It appears that the majority of programs do not use the results of student work to assess their candidates’ teaching abilities. This is a work in progress in at least half of the recommended programs. Programs that said they have such requirements usually require work samples or portfolio entries that include evidence of successful student performance under the candidate’s supervision. Several institutions reported that they were in the process of making this a standing requirement.

In the qualitative responses, about half of the programs appeared to require some consideration of student performance in the assessment of candidate performance, but in most cases did not clearly define how they accomplished this assessment.

Finally, we sought to find out if there were other notable outcomes from the shift to performance assessment, and to obtain an opinion from those involved in this shift as to whether the changes appeared beneficial.

The process of changing to meet the performance assessment standards appears to increase communication among education and science faculty members. Several of the

responses we received in the first survey referred to this effect, and the 80 percent positive response to item six in Table 4 affirmed it quantitatively in the second survey.

One respondent noted, “Benefits will occur from increased collaboration and discussion with our science faculty. We have also probably improved our communication with cooperating teachers in the field related to our expectations.” Another reported “…the best that came out of NCATE was that the content professors, through their chairs, found out how much was at stake if they didn’t change.”

This same individual went on to say, “We have desired a nature of science course for several years. Now we can design one and have it accepted by our science content peers.” A third respondent identified several changes, including “emphasis on inquiry, integration of biology and education courses, [and] increased cooperation between science and education faculty.”

For the most part, respondents to our queries seemed to regard the change to performance assessment to be difficult but worthwhile. Several remarked in their comments that the changes had definitely improved their program. As to whether the changes will benefit the practice of education, 70 percent of the respondents in the second survey agreed that they would (Table 2). Two were not sure and one felt that the changes would not have a positive effect.

The most overtly negative response concerned the time required for bookkeeping, and whether master teachers should have to complete the work sample that NSTA and NCATE asks for. Since NSTA does not require a work sample as such, this individual

appears to confuse standard with implementation. He goes on to note that the work samples required are above the ability of student teachers to complete and that "there seems to be a significant lack of reality in a lot of the additional things that NCATE and NSTA want teacher candidates to know and be able to do."

In contrast, another respondent noted that "outlining expectations and goals, applying appropriate assessment and extending school site experience will benefit the candidates", and another said that "students are getting a more comprehensive understanding of what it means to be a science teacher, what it means to 'do' science, and what is meant by the 'nature of science' etc."

Discussion

The institutions we surveyed had all developed their performance assessment systems within the two years prior to the survey. In some cases, the systems were not complete, and in others, few or no candidates had experienced them. This may in part explain why we did not have a higher response rate.

The responses we received seem to support the shift to performance-based assessment as a way to ensure that the concerns of the science education community, as embodied in the National Science Education Standards, are addressed in preservice preparation.

The degree to which the shift has an impact on student learning still must be determined. The changes in the standards and their use are only first and tentative steps toward more effective preservice teacher education.

It appears, as illustrated by the instance of the "nature of science" response, that the shift to performance assessment has helped to ensure that some areas of concern get the attention they did not receive in the past.

If the responses we received are valid indicators, most teacher educators support the direction of these changes. Several respondents in this sample credited NCATE and NSTA with pushing these changes forward by giving them leverage to effect change.

It is possible, or course, that our positive results stem from the fact that more supportive programs responded to our survey. Even so, the overall model we have constructed supports the conclusion that substantial reform is taking place.

We noted in at least one instance that some respondents still doubt that the profession will sustain the movement toward performance assessment based on external standards. This respondent wrote, "There is a widespread belief that standards-based education does nothing to improve teaching. Some insist it is a fad and will be replaced by something else shortly."

The truth of this assertion will depend to a degree upon further research on the effects of performance assessment on teacher preparation and upon the support of policies and practices that underlie the changes.

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Appendix

1998 NSTA Standards for Science Teacher Preparation

Standard 1 Content. The program prepares candidates to structure and interpret the concepts, ideas and relationships in science that are needed to advance student learning in the area of licensure as defined by state and national standards developed by the science education community. Content refers to concepts and principles understood through science; concepts and relationships unifying science domains; processes of investigation in a science discipline; and applications of mathematics in science research.

a. Demonstrate depth and breadth of subject matter knowledge aligned with state and national standards for their teaching discipline(s).
b. Demonstrate knowledge of unifying concepts and relationships of science as defined by state and national standards.
c. Demonstrate knowledge and skills needed to design, conduct and report investigations within their science discipline.
d. Demonstrate the ability to apply mathematics to data analysis and problem solving within their science discipline.

Standard 2 Nature of Science. The program prepares teachers to engage students in activities to define the values, beliefs and assumptions inherent to the creation of scientific knowledge within the scientific community, and contrast science to other ways of knowing. Nature of science refers to characteristics distinguishing science from other

ways of knowing; characteristics distinguishing basic science, applied science, and technology; processes and conventions of science as a professional activity; and standards defining acceptable evidence and scientific explanation.

a. Demonstrate knowledge of the conventions of scientific evidence and explanation as well as the philosophical and historical nature of science.
b. Engage students effectively in studies of the nature of science and conventions of scientific explanation

Standard 3 Inquiry. The program prepares candidates to engage students regularly and effectively in science inquiry and facilitate understanding of the role inquiry plays in the development of scientific knowledge. Inquiry refers to questioning and formulating solvable problems; reflecting on, and constructing, knowledge from data; collaborating and exchanging information while seeking solutions; and developing concepts and relationships from empirical experience.

a. Demonstrate knowledge of scientific inquiry as a way of developing and imparting scientific knowledge.
b. Engage students effectively in the study of phenomena through inquiry as appropriate for their grade and abilities.

Standard 4 Context of Science. The program prepares candidates to relate science to the daily lives and interests of students and to a larger framework of human endeavor and

understanding. The context of science refers to relationships among systems of human endeavor including science and technology; relationships among scientific, technological, personal, social and cultural values; and the relevance and importance of science to the personal lives of students.

a. Demonstrate knowledge of the relationships among science and other human values and endeavors.
b. Engage students effectively in the study of the relationship of science to other human values and endeavors.
c. Relate science to the personal lives, needs and interests of their students.

Standard 5 Skills of Teaching. The program prepares candidates to create a community of diverse student learners who can construct meaning from science experiences and possess a disposition for further inquiry and learning. Skills of Teaching refers to science teaching actions, strategies and methodologies; interactions with students that promote learning and achievement; effective organization of classroom experiences; use of advanced technology to extend and enhance learning; and the use of prior conceptions and student interests to promote new learning.

a. Use diverse and effective science teaching actions, strategies and methodologies.
b. Promote learning and achievement.
c. Organize classroom experiences effectively
d. Use advanced technology to extend and enhance learning.

e. Use prior conceptions and student interests to promote new learning.

Standard 6 Curriculum. The program prepares candidates to develop and apply a coherent, focused science curriculum that is consistent with state and national standards for science education and appropriate for addressing the needs, abilities and interests of students. Science curriculum refers to an extended framework of goals, plans, materials, and resources for instruction and the instructional context, both in and out of school, within which pedagogy is embedded.

a. Develop coherent, meaningful goals, plans, and materials and find resources.
b. Relate plans and resources to professionally developed state and national standards, including the National Science Education Standards.
c. Plan and develop science curriculum addressing the needs, interests and abilities of all students at the appropriate level.

Standard 7 Social Context. The program prepares candidates to relate science to the community and to use human and institutional resources in the community to advance the education of their students in science. The social context of science teaching refers to the social and community support network within which science teaching and learning occur; relationship of science teaching and learning to the needs and values of the community; and involvement of people and institutions from the community in the teaching of science.

a. Know and understand the values and needs of the community and their effect on the teaching and learning of science.
b. Use community human and institutional resources to advance the learning of science in the classroom and field.

Standard 8 Assessment. The program prepares candidates to use a variety of contemporary assessment strategies to evaluate the intellectual, social, and personal development of the learner in all aspects of science. Assessment refers to the alignment of goals, instruction and outcomes; measurement and evaluation of student learning in a variety of dimensions; and the use of outcome data to guide and change instruction.

a. Align science goals, instruction and outcomes.
b. Use a variety of contemporary science assessment strategies to determine student needs and levels of learning and development.
c. Use assessment appropriately to determine, guide and change science instruction

Standard 9 Environment for Learning. The program prepares candidates to design and manage safe and supportive learning environments reflecting high expectations for the success of all students. Learning environments refers to the physical spaces within which learning of science occurs; psychological and social environment of the student engaged in learning science; treatment and ethical use of living organisms; and safety in all areas related to science instruction.

a. Create and maintain a psychologically and socially safe and supportive learning environment.
b. Manage the activities and materials of science safely in storage areas, labs and field.
c. Keep and use living organisms as in the classroom in a safe, ethical and appropriate manner

Standard 10 Professional Practice. The program prepares candidates to participate in the professional community, improving practice through their personal actions, education and development. Professional practice refers to knowledge of, and participation in, the activities of the professional community; ethical behavior consistent with the best interests of students and the community; reflection on professional practices and continuous efforts to ensure the highest quality of science instruction; and willingness to work with students and new colleagues as they enter the profession.

a. Know and participate in professional organizations and activities of the science education community beyond the classroom.
b. Behave ethically and in best interests of preK-12 students and the community.
c. Engage in reflective practices and make continuous efforts to improve in practice.
d. Work willingly with peers, supervisors and others in a professional manner.