DOCUMENT RESUME

ED 475 159 SE 067 669

AUTHOR	Burry-Stock, Judith A.; Casebeer, Cindy M.
TITLE	A Study of the Alignment of National Standards, State Standards, and Science Assessment.
PUB DATE	2003-03-23
NOTE	16p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (Philadelphia, PA, March 23-26, 2003).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	Curriculum Development; Educational Change; *Educational Policy; Elementary Secondary Education; *Evaluation; *National Standards; Science Education; Standardized Tests; *State Standards

ABSTRACT

Educational reform efforts are currently at the top of the nation's agenda. Policymakers are hearing increasing calls from members of the public to improve standardized test scores. These reform calls are a response to the perceived inadequacy of science teaching in our nation. Data were collected from participating states regarding the status of the adoption of science standards and their alignment with the National Science Education Standards and the AAAS Benchmarks. Additionally, hierarchical information was collected on the match between curriculum and assessment. A coding scheme was designed to assess the refinement of standards and the availability and match of science testing. Data were collected twice from state departments of education over a four-year period to ascertain the match between standards, curriculum, and assessment. A significant difference was found in the number of states that now require science standards and standardized testing. Alignment of standards, curriculum and assessment prevailed in 2002. The fact that states are requiring testing in science reflects the national concern for educating our students in science, even if we do not believe that standardized testing accurately reflects effective teaching and learning. (Author)

A Study of the Alignment of National Standards, State Standards, and Science Assessment

Judith A. Burry-Stock
The University of Alabama
jstock@bamaed.ua.edu
bama.ua.edu/~jstock/

Cindy M. Casebeer
The University of Alabama
ccasebee@bamaed.ua.edu

Paper presented at the National Association for Research on Science Teaching, March 23, 2003, Philadelphia, PA

Draft March 2003

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Judith A. Burry-Stock
The University of Alabama
jstock@bamaed.ua.edu
bama.ua.edu/~jstock/

Cindy M. Casebeer
The University of Alabama
ccasebee@bamaed.ua.edu

Abstract

Education reform efforts are currently at the top of the nation's agenda. Policymakers are hearing increasing calls from members of the public to improve standardized test scores. These reform calls are a response to the perceived inadequacy of science teaching in our nation. Data were collected from participating states regarding the status of the adoption of science standards and their alignment with the National Science Education Standards and the AAAS Benchmarks. Additionally, hierarchical information was collected on the match between curriculum and assessment. A coding scheme was designed to assess the refinement of standards and the availability and match of science testing. Data were collected twice from state departments of education over a four-year period to ascertain the match between standards, curriculum, and assessment. A significant difference was found in the number of states that now require science standards and standardized testing. Alignment of standards, curriculum, and assessment prevailed in 2002. The fact that states are requiring testing in science reflects the national concern for educating our students in science, even if we do not believe that standardized testing accurately reflects effective teaching and learning. This project was done with funding from the National Science Foundation for the National Institute for Science Education (NISE) housed at the University of Wisconsin and the National Center for Science Education in Washington, DC.

A Study of the Alignment of National Standards, State Standards, and Science Assessment

Introduction: Education Reform in Standards and Testing

Reform efforts in school science have been at the top of the nation's agenda for the past decade and a half. The reforms are a response to the perceived inadequacy of high school graduates in terms of the job market, entrance to college, student motivation for pursuing careers in science/engineering/technology, and producing a scientifically/technologically literate citizenry.

The beginning of the push for national education standards was the formulation of the legislation that ultimately became *Goals 2000: Educate America Act* of 1994. On March 31 of that year President Clinton signed the bill into law. He is quoted as saying (in Jennings, 1998) "This is the beginning. It is the foundation. Today we can say America is serious about education ...[*Goals 2000*] sets world-class education standards for what every child at every American school should know in order to win when he or she becomes an adult. We have never done it before. We are going to do it now because of this bill" (p.108).

On January 8, 2003 President Bush signed into law the *No Child Left Behind Act* of 2002 (NCLB). This law is intended to bring sweeping changes to the Elementary and Secondary Education Act (ESEA) that will impact American's schools kindergarten-through-grade12 education. The act requires a stronger accountability for educational results, with an increase in flexibility and local control. According to the US government website for *No Child Left Behind Act* (2003) the "accountable" education system involves several critical steps, which include that "states create their own standards for what a child should know and learn for all grades. Standards must be developed in math and reading immediately. Standards must also be developed for science by the 2005-2006 year. With standards in place, states must test every student's progress toward those standards by using tests that are aligned with the standards. ... Beginning in the 2007-2008 school year, science achievement must also be tested" (p.1).

Science Standards

The purpose of this paper is to present the status of standards and testing in science throughout the US. At three time intervals states the existence of science standards and science standards and testing alignment were researched. No attempt is made to determine the quality of standards or assessment instruments, but merely to examine the status of science standards and assessment. In order to put this study in context we need to attend to the two sets of national science standards.

The U.S. (the world?) has never seen two more gigantic reform initiatives than Project 2061 (AAAS, 1988; Rutherford & Ahlgren, 1989), a project of the American Association for the Advancement of Science (AAAS) supported by Carnegie and Mellon Foundations as well as the National Science Foundation (NSF) and Scope, Sequence, and Coordination (SS&C) (Aldridge, 1992: Yager, 1993), a project of the National Science Teachers Association (NSTA) supported

by NSF, the Department of Education, and industries such as the American Petroleum Institute. Each of these projects has attracted support in excess of $20 million.

Both Project 2061 and SS&C have influenced the final version of the *National Science Education Standards* (NSES) by the National Research Council (NRC, 1996), the National Academy of Science, with $7 million support over a four-year period involving over 3,000 professionals. And, these *Standards*--finalized and distributed in December 1995--represent well the reform. The hope is, that the *Standards* will hasten the reforms and move the nation into meeting of our national Goals 2000: Educate America Act of 1994 (Jennings, 1998), especially as they pertain to science and mathematics. Of course, advances and improvement of school science and mathematics are intimately related to general reform of the nation's schools.

However, are standards alone enough to strengthen science achievement in our educational institutions, K-graduate levels? Results of the Third International Mathematics and Science Studies ranked the US near the top of grade four and in the lower middle of grades 8 and 11 (Martin, 1996). These studies are the most ambitious to date examining about 45 countries at three grade levels, and they indicate that the US has a ways to go to be a world leader in K-12 education.

According to Webb (1997), "Assuring the alignment between expectations and assessments can strengthen an education system in important ways. Teachers give more credence to documents they understand are in agreement, are useful, and will serve to benefit their students. Teachers, already overloaded with responsibilities are better able to attend to expectations and assessments if they provide a consistent message and have credibility."

Purposes of Science Testing

Often the rationale for assessing student learning in science is to improve science instruction, science programs, report information to students, parents, teachers, and administrators regarding the status of individuals, classes, school districts, states, and ultimately the nation, as in TIMSS, thus making educators accountable (Raizen, Baron, Champagne, Haertel, Mullis, & Oakes, 1989). Types of achievement that are generally assessed "...include knowledge of facts and concepts, science, process skills, science thinking and problem solving skills, skills needed to manipulate laboratory equipment, and the disposition to apply science knowledge in skills (Raizen, Baron, Champagne, Haertel, Mullis, & Oakes, 1991; Swain, 1985). According to Doran, Lawrenze, and Helgeson (1994), who wrote the seminal chapter on research on assessment science, "It is widely accepted that achievement tests strongly influence and direct curriculum development" (p. 395). It is impossible to overlook the impact of assessment. Shavelson, Carey, and Webb (1990) stated that "Developers of scholastic tests have become overseers of a very powerful instruments of education policy making: achievement tests" (p. 692).

Method

Testing coordinators and curriculum specialists at state departments of education were contacted in summer 1998, summer 2001, and summer 2002. All three times the status of science standards and the match between curriculum and testing were ascertained. The questions

for 2001 and 2002 were done by email, while the earlier questions were asked by phone. Email questions were more direct and elicited clearer responses. This may also be a function of states being more involved in science standards and testing on science content in 2001 and 2002 than they were in 1998. Table 1 details information requested by email. Telephone conversations in 1998 addressed the similar questions. Viewing state department information on their websites followed responses. A website with hotlinks to state departments of education was created in order to access their standards and testing information. The url for the website is bama.ua.edu/~jstock/.

Table 1. Email Questions and State Reporting Form

Standards Information

- State
- Are state standards in place? (Yes or No)
- Are your state standards aligned with what national standards? If so, are they the National Science Education Standards (NRC), the Benchmarks (AAAS), or other?
- What grade levels are covered by the standards

Testing Information

- Is a science-testing program in place? (Y or N)
- Grade level(s)
- Test(s) used
- Writer(s) of test(s)
- Are tests norm-referenced (NRT) or criterion-referenced (CRT)?
- Description of how tests match standards (very closely match, closely match, etc.)

States were assigned a coded value based upon the information provided regarding the nature of their science standards and science testing. Coding went as follows: 0) No response; 1) No curriculum standards/no assessment in science: 2) adoption of national standards/state standards - no science assessment; 3) standardized test (no curriculum alignment with standards); and 4) Assessment aligned with state/national standards. See Table 2. An example of the coding for the state of Alabama can be found in Table 3--Alabama has state standards that are aligned with national standards. The state was given a 4 on the match between standards and testing given the data provided on the Alabama State Department website. The state tests in science using the Stanford 9 at grades 4,5,7, and 9 and the High School graduation examination at grade11 and 12. Those who do not pass the exam in grade 11 must retake the exam in grade 12. The exams are both norm referenced and criterion referenced. This procedure was followed for

all 50 states, Washington DC, and Puerto Rico. A caveat should be noted in that states are constantly in the process of changing standards and assessments; therefore, things may have changed between the time that these data were collected and now.

Table 2. Coding for Correspondence Between Standards and Assessment

Code	Explanation
0	No Response
1	No Curriculum Standards/No Assessment In Science
2	Adoption Of National Standards/State Standards - No Science Assessment
3	Standardized Test No Curriculum Alignment With Standards
4	Assessment Aligned With Local/ State/National Standards

Table 3. Example for Coding the Correspondence Between Standards and Testing.

State	Assessment Coding	Name Of Test And Publisher (Including Form And Edition)	Grade Levels Tested	Type Of Assessment (CRT Or NRT)
Alabama	4	Stanford 9 by Harcourt Brace Education Measurement, Alabama High School Graduation Exam (AHSGE)	4, 5, 7, 8 – Stanford 9 10, 11 - AHSGE	NRT and CRT

Data Analysis

Approximate frequencies were tabulated based upon coded data for 1998, 2001, and 2002. These data included projections for the ensuing school year. Approximate frequencies are used here, because it was sometimes difficult to determine the outcome based upon the response. This was especially true in 1998. Table 4 details the frequencies for each coded level. For example, in 1998 17 states had no curriculum standards in science, while in 2001 there were two and in 2002 there was only one. Table 5 lists the percentages of state coding from the preceding table based upon the 50 US states, Washington DC, and Puerto Rico. For the coded level one, 33 percent of the states did not have any curriculum standards in science, while in 2001 there was 4 percent and in 2002 there was only 2 percent. Some states are not represented because information was not obtained either by email or was not available on the state's web site. A chi square analysis was done on the frequencies where $p = .19$. This means that the probability that

these data occurred by chance alone is .19, which is not statistically significant. However, there may be practical significance, given that there is a definite upward trend.

Table 4. Coded Frequencies for State Data for Years 1998, 2001, and 2002.

Year	Code				
	1	2	3	4	No Response
1998	17	4	18	0	13
2001	2	10	4	28	8
2002	1	11	2	34	4

N = 52 (50 states plus Washington DC and Puerto Rico)

Table 5. Percentage Comparisons of Coded Data for Years 1998, 2001 and 2002

Year	Code				
	1	2	3	4	No Response
1998	33	08	35	00	.25
2001	04	19	08	54	.15
2002	02	21	04	65	.08

N = 52 (50 states plus Washington DC and Puerto Rico)

Standardized tests used for statewide science assessment included: Stanford 9 published by Harcourt Educational Measurement; TerraNova published by CTB/McGraw Hill; and Iowa Tests of Basic Skills published by Riverside Publishing. These main publishers were often the contractors for adaptations of tests or item generation for various state departments. States writing some form of their own tests are listed in Table 7. These data in particular are subject to interpretation based upon provided information from the questionnaire and the web site. Since many states are in a state of flux some of this information may have changed since these data were collected.

Table 6. Standardized Tests And The Frequencies .

Standardized Tests And Their Publishers	Frequencies And States
Stanford 9 (Harcourt Educational Measurement)	5 (Alabama, California, Georgia, Oklahoma, West Virginia)
California (Standards Tests?) (Harcourt Educational Measurement)	2 (California, Minnesota)
TerraNova (CTB/McGraw Hill)	4 (Nevada, New Mexico, South Carolina, Wisconsin)
Iowa Test of Basic Skills Iowa Test of Educational Development	3 (Iowa, Minnesota, Nevada)
Third International Math and Science Study (TIMSS)	1 (Minnesota)
National Assessment of Educational Progress (NAEP)	1 (Minnesota)
Metropolitan Achievement Test, 7th edition (MAT7)	1 (Minnesota)

Table 7 State Written/Contracted Standardized Tests.

Test Name	States
Alabama High School Graduation Exam	Alabama
Golden State Exam	California
California Standards Test (Harcourt Educational Measurement)	California
Connecticut Academic Performance Test (Harcourt Educational Measurement)	Connecticut
Delaware Student Assessment Program (Harcourt Educational Measurement)	Delaware
Kentucky Core Content Test	Kentucky
Maine Educational Assessment (Measured Progress)	Maine
Maryland School Performance Assessment Program (Publisher: CTB/McGraw Hill)	Maryland
Massachusetts Department of Education	Massachusetts
Michigan Department of Education	Michigan
Subject Area Testing Program (Harcourt Educational Measurement)	Mississippi
Missouri Assessment Program (CTB McGraw Hill)	Missouri
NH Teachers (Outside Contractor)	New Hampshire
New Mexico Supplement	New Mexico Supplement
Elementary Level Science Test Intermediate Level Science Test New York Regents Examination	New York
NC Department of Public Instruction	North Carolina
Oklahoma End of Course Exams	Oklahoma
Oregon Department of Education	Oregon
Palmetto Achievement Challenge Test (PACT)	South Carolina
Dakota Assessment of Content Standards (DACS) (EdVISION)	South Dakota
Tennessee Course Assessment Program (TCAP) (CTB/McGraw Hill	Tennessee
Texas Assessment of Knowledge and Skills (TAKS)	Texas
Vermont-Partnership for the Assessment of Standards-based Science (PASS) (WestEd & ETS)	Vermont

Table 6. State Written/Contracted Standardized Tests (cont).

Standards of Learning (SOL) (Harcourt Educational Measurement)	Virginia
Wisconsin customized TerraNova	Wisconsin

Conclusions

Many more states presently test in science than in 1998, and there has been an increase in the match between states' science standards and their testing programs. Since AAAS's (1988) initial plea for "science for all Americans" this is a major accomplishment for the US, even though the percentages indicate a steady increase in the number of states with science testing aligned with standards. We have gone from 0% to 66% in four years; however, there is still room for improvement. As was stated previously, the US ranked high in the TIMSS study for only 4th grade and we were only mediocre for grades 7 and 11. Many states have included aspects of performance assessment, which moves us to a higher cognitive level of testing for the most part. Most states involve testing companies as contractors, but do not use a complete test out-right, which says something for state initiatives. Still many states rely on standardized testing from some vendor to supply them with items. Since the standards came first, we can make the assumption that they have driven achievement testing in science, but can we assume that this is for the better? However, we can assume that state departments of education are paying more attention to science education. With the current *No Child Left Behind Act* (2003) we can assume that in some way states will have a science standards and a science testing program in place by 2007-2008 for grades 3 through 8. Hopefully, this type of study will be conduced again by 2008.

There is a caveat in that even though we have a definite increase in science achievement, the TIMSS suggests that we not rest in our quest for getting science into our classrooms. The National Assessment for Educational Progress (NAEP) studies place the majority of students at a basic level of science understanding. The three NAEP levels are: 1) basic; 2) proficient; and 3) advanced. A very small percentage (around 1-4%) is at the advanced level of understanding.

Is there validity and value in statewide assessment of science? Most of the tests used are valid in that they reflect the interests of the various states. Many of them are indeed excellent tests. Is there value in these assessments? This is a value judgment. There are those who do not believe in standardized testing at all for science, in which case the answer is "no." However, if we never had a ruler or a yardstick we would not know how long things are. By the same token, if we did not have assessments we would not have any achievement indicators. These tests do measure achievement even if they are flawed in some or many ways. If we look at these tests as crude measures with a lot of variability, they do provide us with valuable information.

In order to prepare today's students for tomorrow's world we need to reculture today's schools. In order for reculturalization to happen, we need to implement successful systemic changes. We need to manage change of the critical masses by using continuous strategies that are most likely to mobilize large numbers of people in new directions (Fullan, 1996). According to Fullan "...systemic reform is partly a matter of redesigning the objective systems of interrelationships so that obvious structural faults are corrected. However, it mainly involves

strategies (such as networking and reculturing) that help develop and mobilize the conceptions, skills, and motivation in the minds and hearts of scores of educators" (p. 422).

Standards and tests may not be the answer for achieving a high level of science literacy, but they do provide a type of momentum for reform. It is up to the teachers, educators, and researchers to make sure that they provide information and the interpretation that will enable us to examine science achievement. Hopefully, these tests will provide a vehicle for promoting the learning of science for all students. It appears that states and policy makers are moving to make educators more accountable in science. Aligning standards and testing is a major contribution to observable accountability. Whether or not we are teaching and testing "science for all Americans" and whether we are producing students who are literate remains to be seen. Assessment is only one way of seeing and our observations may be in error; however, are there more accurate ways of seeing?

Acknowledgments

Partial funding for this study came from a fellowship granted to Judith A. Burry-Stock from the National Institute for Science Education (NISE) housed at The University of Wisconsin and the National Center for Improving Science Education in Washington, DC. The National Science Foundation funded the original grant.

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Signature: Judith A. Burry-Stock	Printed Name/Position/Title: Judith A. Burry-Stock
Organization/Address: Box 870231, Ed Research, The University of Alabama, Tuscaloosa, AL 35487	Telephone: 205-348-1187 FAX: 205-348-0683
	E-Mail Address: jstock@bamaed.ua.edu Date: 4/15/03