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Reaching the standards: An action research project using a constructivist survey to measure the effects of curricular change based on the goals of the National Science Education Standards

Kristi Joanne Mueller

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REACHING THE STANDARDS:
AN ACTION RESEARCH PROJECT USING A CONSTRUCTIVIST SURVEY TO MEASURE THE EFFECTS OF CURRICULAR CHANGE BASED ON THE GOALS OF THE NATIONAL SCIENCE EDUCATION STANDARDS

A Project
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
in
Education:
Secondary Option

by
Kristi Joanne Mueller
June 1998
REACHING THE STANDARDS:
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Approved by:

Dr. Herbert Brunkhorst, First Reader 3/19/98
Date

Dr. Bonnie Brunkhorst, Second Reader
ABSTRACT

In this project Teaching Standards A and B of the National Science Education Standards were used as guidelines for establishing a classroom environment conducive to inquiry learning. A modified version of the Classroom Learning Environment Survey (Taylor 1995), was administered to students at the beginning of the school year, after six weeks of regular instruction, and at the end of the quarter after participating in an independent project, to gather information on the students' impressions of the altered classroom environment. The findings of the modified CLES indicate that students' impression remained stable during the time period indicated, even when changes occurred in the type of instruction given. Individual analysis of the results did indicate some students' impressions changed.
ACKNOWLEDGMENTS

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INTRODUCTION

Education has been a cornerstone of our society since the thirteen colonies were established. The great educator Horace Mann claimed that it was the avenue to creating an informed, educated citizenry (Ornstein, 1993). Our society continues to consider education an important objective, and the performance of our students on international tests is an indicator to society of the success of education programs. At the 1991 educational summit President George Bush and the state governors set a goal that the United States would score at the top in Math and Science by the year 2000 (Marzano, 1993), but the 1996 results of the Third International Math and Science Study (TIMSS) fall short of this goal (Colvin, 1996). The U.S. scored 17th in Science and 28th in Math out of forty five nations (TIMSS, 1996), causing yet another wave of reform to sweep the education system.

Reform begins with the perception of the need for change. This is often established through publications by significant people (Bybee, 1993). 1983 marked the twenty-fifth anniversary of Sputnik and provided an occasion to ask how things were in science and technology education (Bybee, 1993). The answer provided by John Slaughter, a former director of the National Science Foundation, was that there was "a growing chasm between a small scientific and technological elite and a citizenry ill-informed, indeed uninformed on issues with a science component (National Commission, 1983). In the same year A Nation At Risk (1983) was published, and in it Paul Hurd, a widely recognized science educator, claimed "we are raising a new generation of Americans that is scientifically and technologically illiterate" (National Commission, 1983).

Elaborating on these perceptions and addressing their solutions can result in action such as new curriculum materials, or increased graduation requirements. New model curriculum standards, textbooks, standards of teaching, and assessment materials may be developed to support the new ideas (Tobin, 1994). The first step of this reform has been accomplished with the publication of materials such as Second to None (California
Department of Education, 1992), and the *National Science Education Standards* (National Research Council, 1996). These materials provide guidelines and examples of how to reach the future goals (Bybee, 1993). The Department of Labor's *What Work Requires of Schools* identifies standards for discipline knowledge and lifelong learning that are important in the workplace, such as creative thinking, decision making, problem solving, collaborating, learning how to learn, and self management. This decade has also seen the growing need for significant change in assessment. The “back to basics” movement of the 1970’s with its low level functional skills and minimum competency tests has been replaced by higher standards and more sophisticated goals of the 90’s like performance assessment (Marzano, 1993).

Recommendations from TIMSS indicate that some countries with national standards perform better than the United States in Math and Science, although other countries that also performed better than the United States did not have national standards (Sutton and Krueger, 1997). Will the recently published National Science Education Standards (NSES) improve the performance of students on such tests? This question must be answered if the time and money spent to create these standards will have an effect on actual teaching practices.

The easy part of reform is setting goals and suggesting changes. It is much more difficult to implement and achieve these goals. Success rests on understanding and applying the three stages of reform: Identification, implementation, and assessment. For the present reform to succeed, it must reach beyond the first stage of preparing materials that meet its goals, to the actual implementation of the curriculum and ideas. One problem seems to be translating material into something that can be used by the majority of classroom teachers. Paul Hurd wrote in 1971,

> Since 1893 there have been 40 major efforts to reform the teaching of high school science. None have had more than a temporary salutary effect on science education. Committees recommended new goals and course content, but it was never carried out where it could be used by a classroom teacher without writing or revising a course of study.

Providing new standards or requiring the administration of a new standardized test
may not significantly affect what goes on in the classroom (Bybee, 1993). Educational reform must focus on the preparation and continuing education of teachers, and the restructuring of the schools (Tobin, 1990), and we can expect the burden of the implementation of these changes to be placed on the local school districts and teachers. This of course is necessary, since they know the needs of their schools, students, and community. But help from the colleges, universities, state, and federal government will be necessary if these reforms are going to succeed (Bybee, 1993). Classroom teachers cannot solve all the problems in education by themselves (Caine, 1991).

The final step is the relative success of the new program. Many programs once implemented do not solve the problem identified in the first step, are not accepted by the public, or create new problems. Others that are successful last until society changes enough to require a new set of reforms. The cycle begins again as programs are refined, replaced with new ideas, or allowed to return to traditional methods. By measuring student response with a tool such as the Constructivist Learning Environment Survey (CLES), the awareness and effectiveness of the reform can be measured (Taylor, 1995). Reforms must be applied by teachers and recognized and accepted by students before we can expect to see any results. Perhaps today, with large numbers of educators and students that desire a genuine change, we can be successful (Caine, 1991).

The goal of this study is to apply selected standards of the NSES to a science classroom and measure the results, bringing reform to a local level. Revision of the Biology course materials used at Rim of the World High School will include planning and implementation of an inquiry based science program with a focus on Teaching Standards A and B of the NSES. Short term and year long goals for the course will be developed that guide and facilitate student learning, and challenge students to accept responsibility for learning in an environment that is flexible and supportive of student inquiry. These changes will be measured with a modified version of the Constructivist Learning Environment Survey, concentrating on the area of shared control.
LITERATURE REVIEW

The National Science Education Standards (NSES) propose changes in many areas of science education, from teacher preparation to curriculum guidelines. A science program, aligned to the NSES, would be developmentally appropriate and interesting to students. Science would be integrated with other subjects, especially mathematics. Assessment would be based on actually measuring the intended goals (NRC, 1996). The NSES outlines six Standards of teaching that incorporate much of this vision into practical suggestions teachers can apply to the classroom. But many of these ideas are not new, and have been a part of science education theory for a long time. The problem has been in the translation and application of these proposals to the classroom.

It is interesting to look at the history of science education in the United States to see how different issues have affected the direction and success of various reform movements. Many of the problems seen in today’s science classrooms have been problems for a century, while others are products of the changes that our society has gone through in the last one hundred years.

In Teaching Standard A teachers of science plan an inquiry based science program based on a curriculum designed to meet the interests, abilities, and experience of the students (NRC, 1996). Thematic units that allow students to engage their emotions, build social relationships, and participate in complex processing through intellectual challenge should be emphasized. Leo Wood, a chemistry teacher in Tempe Arizona, plans his chemistry course using the overriding theme, “Life is a Miracle”. Chemistry is explored as the central science that responds to the needs of society (Caine, 1991).

An inquiry based science program is not a new idea. One of the first institutions to include science in the courses offered was the Franklin Academy, founded by Benjamin Franklin in the mid 1700’s. Since Franklin had a great interest in science and invention and made important contributions in this field, it is no surprise that his academy was also the first to encourage the study of science, invention and technology (Ornstein, 1993).
Other academies also began to promote the study of science, a change from the classical curriculum favored by most secondary schools of this time. (DeBoar, 1991). The great leaps in science, technology, and industry caused great changes in society and educational thinking, as well as the curriculum. The practical applications of these topics that had been viewed as crass and materialistic by the old educational system, were now providing answers to society’s problems in public health and human welfare. Many educators even looked to science to provide insights into learning theory. Pestalozzian education was based on the natural development of the child’s mental faculties, and the study of natural objects was an important part of this educational practice (DeBoar, 1991).

Science education is just as important in today’s society. Many of the global issues center on topics related to science and technology. People are asked to vote on issues that can have long term environmental effects. New medical discoveries pose ethical problems that must be resolved. Science education must provide students with the ability to understand these topics, and make informed decisions (A.A.A.S., 1988). We have also developed a more comprehensive picture of learning which may better equip education in reaching the goals of reform (Caine, 1991).

Unfortunately, since the 1800’s, the actual teaching practices in many of the science classes have lagged far behind the educational theories, mainly because of a shortage of well prepared teachers and materials. The instruction of secondary science courses in the early academies was not of high quality due to poor teacher preparation, a course length of as little as six weeks, and inadequate materials and textbooks. This led to classes that were primarily taught from books, with little actual application. Most teaching at this time centered on the memorization of facts and recitation of these facts to the teacher. This rote learning was reinforced by the type of testing that was utilized (Hurd, 1971, DeBoar, 1991). Charles Eliot, president of Harvard in the late 1800’s, exclaimed that there was “little profit in studying natural science in a book as if it were grammar or history” and if such were the case, better to not study it at all (Hurd, 1971).

These problems continue to be an issue in today’s science classroom. In many instances teachers are required to teach out of their subject area, decreasing their
effectiveness in the classroom and increasing the amount of errors and reliance on the
textbook. A study by Stake and Easly in 1978 showed that most teachers teach basic facts
and definitions from the textbooks. Academic work is directed toward earning points and
preparing for tests that require the recall of factual information or application of procedures.
In Goodlad’s *A Place Called School* the dominant teaching procedure identified was
lecturing (Tobin, 1990).

The problem does not only exist in the high school setting. Universities are deeply
trenchent in the lecture mode of teaching. By the time teachers experience innovative and
creative ways of teaching, they also have experienced a minimum of 14 to 16 years of
lecture and memorization. It is extremely difficult to turn the resulting ingrained habits
around in the three to four courses required by most state legislatures for teacher
credentialing. In addition, many of those education courses are taught in the traditional
mode. Many teachers want to hold on to traditional methods and teach the way they were
taught (Caine, 1991).

It is interesting to note that as secondary schools became more popular, the first
reform tried to accomplish many of the goals we are striving for today. Many of the
traditions we find in the secondary science curriculum were established in 1892 by the
Committee of Ten. The National Education Association appointed this committee to
standardize the secondary curriculum (Raubinger, 1969). The committee recommended
that twenty-five per cent of a student’s study should be devoted to science, and Charles
Eliot, chairman of this committee, said that the study of science was “a way to develop
mental abilities and empower persons for useful action in their lives”. The committee also
suggested the present order of high school science topics, and considered laboratory work
essential for every science class. Besides the scheduled double lab periods, they
recommended one hour a week spent out of doors for nature study, and Saturday labs for
longer exercises (DeBoar, 1991). The use of lab tests and notebooks was encouraged for
complete assessment of the students’ knowledge in the science subjects.

Some of these standards proposed by the Committee of Ten over one hundred
years ago are included in the NSES today, while other standards are no longer relevant in
today’s high school. In 1892, high school was mainly attended by students preparing for college, a select student body representing a small fraction of those actually in this age group. By the early 1900’s, the growth of the high school population due to compulsory education, child labor laws, and the increasing affluence of an industrialized nation, made secondary education possible for many more students with many other goals than that of college. A counter movement to make the curriculum more meaningful to those students not going on to college challenged many of the ideas of the Committee of Ten. In 1918, the Commission on the Reorganization of Secondary Education issued Seven Cardinal Principles of Education that provided a framework based on process rather than content. After World War I the Progressive Movement began to challenge the idea of the same education for all students and was active for the next thirty years.

The impact on science education was immediate. Many students did not want to take four years of science. Enrollment in science classes did not follow the growth trend of the public high school, and in fact declined in physics and chemistry. During the 1920’s science courses were viewed as difficult by students, especially chemistry and physics, and the labs were mainly simple verification or observation for mental discipline. The majority of science textbooks were written by scientists teaching in college and they chose content that was reasonable to them, especially in light of their research or special interest (Hurd, 1971). Most students completed one, or maybe two science courses before graduating.

The Committee of Ten had recommended that 25 per cent of the time in high school be spent on science education, but over time it had slowly been decreased. The average number of years students enrolled in science courses had dropped from four to two, and once the students taking three or four years were taken into account, many students were only taking one year of science (DeBoar, 1991). Even today, most high schools require only two years of science to graduate.

John Dewey, a prominent leader in the Progressive Movement of the 1920’s, encouraged the inclusion of science in the curriculum. But application and student interest seemed to be in conflict with the content of the disciplines. John Dewey felt the two needed to be combined to be effective. He did not support the current topic method of his
day any more than the book method and said in regards to picking topics based solely on
student interest, “No amount of this will make an introduction to education, to say nothing
of science, for an introduction leads or draws into a subject, while this method never, save
by accident, gets the pupil within range of problems and explanatory methods of science”
(Hurd, 1971).

The general practice of science teaching fell far below Dewey’s standards. His
background of three years as a high school teacher gave him an understanding of the
problems faced in a classroom (Dykhuizen, 1973). Dewey deplored the use of
memorization and exclusive use of textbooks rather than lab, but also did not believe in
only lab without tying it to the underlying principle of the subject. The problem of exciting
student interest with socially relevant problems while maintaining a continuity with the
principles of the disciplines was a concern in planning the science curriculum. John Dewey
sought to include both by the mastery of the organized principle through problem solving
(DeBoar, 1991). Unfortunately this method was difficult to apply to most high school
science classrooms.

Other areas of concern about the logistics and methods of teaching science also
surfaced. Fixed lab days to accommodate the double lab periods made it difficult to be
flexible in lab assignments and order. The interchange between the lab and class
discussion essential for problem solving was difficult. Also the time and space the lab took
up as student enrollment increased became a more important concern. Through early
educational studies with newly developed standardized tests, evidence was found to
support the efficiency of single period labs, and the use of teacher demonstrations in place
of some exercises. While it was not suggested that the lab be replaced completely, some
schools tried to, mainly based on economic concerns (DeBoar, 1991). As lab class sizes
went from six students to much larger class sizes, it became difficult in terms of supplies
and individual instruction time to present labs in an educationally appropriate manner
(Woodhull, 1918).

World War II, the resulting competition with the Soviets, and perceived threats to
U.S. security swung education back to a more traditional approach that was result oriented.
Science courses in particular fell short of expectations and needed to be revised. Fifty years of effort to make science meaningful to students had satisfied neither the progressives or the traditionalists, and now the progressive movement was essentially over. The National Science Foundation and the National Defense Education Act sought ways to infuse more intellectual vigor into the science courses (DeBoar, 1991).

In the years following the war an increase in requirements, especially in the areas of mathematics and science were seen as necessary to improve our ability to compete with other countries in a technological world. The launch of *Sputnik* in 1957 alarmed the nation, and schools were blamed for the inadequacies of the country in technological areas (Raubinger, 1969). This led to a wave of curriculum reform to increase our ability to produce engineers and scientists for the budding space and defense programs. The goal was to enhance the quality of education, especially for the academically talented. High academic standards and a strong basic curriculum including science were proposed in an effort to prepare people for a more technological society (Bybee, 1993). The reforms were mainly forced by public pressure and criticism, although there was some teacher and educational input (Hurd, 1971).

But the Civil Rights movement of the 1960’s again brought to light the need for equal education focused on student needs. Science courses were expected to remain rigorous while addressing social, environmental and technological issues. The later years of the 1960’s and early 1970’s saw a backlash against the technologically driven curriculum meant to produce scientists and again demanded reform that would bring attention to all students. Many students and educators wanted other subjects emphasized in the curriculum, and they argued that the schools had become too large and impersonal to address the needs of all students (Bybee, 1993).

The goal of educating all students and meeting their needs was an important one, but the curriculum became homogenized and diluted as a result (National Commission, 1983). While it was a mistake in the 1960’s to orient science programs exclusively to the development of future scientists (Bybee, 1993), the role of science in the general education curriculum of the 1970’s was unclear (DeBoar, 1991). More students were graduating
from high school than before WWII, but they were not as well educated as the graduates of that time (National Commission, 1983). There was a steady decline of achievement in science from 1969-1977. Despite the earlier reform, science continued to be taught and tested as a body of factual knowledge, and the new idea of applying science to socially relevant problems was difficult to accomplish. Most students, especially when given the choice, were still not continuing their science education beyond one, or maybe two years in high school (DeBoar, 1991).

In 1983 *A Nation At Risk* highlighted the continuing problems in science education. High school science struggled with maintaining high academic standards, while relating the curriculum to relevant problems to make it interesting to the students so they would continue to take science. The current reform movement is working to combine these goals by providing a rigorous curriculum in a varied and rich learning environment that meets the needs of all students. The new standards provide a vision of all students participating in the same programs, but the concern is that this may not allow a course to be rigorous enough for those planning to continue in science at the universities (DeBoar, 1991). The NSES can help provide direction in curriculum choices to teachers nationwide, but the universities and colleges must also accept these standards as preparation for their courses.

How can this reform succeed, when previous ones have not? The past two decades have seen exciting new advances in how learning occurs. Learning involves active construction of meanings by the learner. The learner assimilates new experience into the existing structure they have accumulated (Vance, 1996). The NSES Teaching Standard A promotes an inquiry based approach that would be utilized to interest and direct student learning. Instead of being used for mental exercise or as an answer to society’s problems, science would be presented as a way of thinking and analyzing (DeBoar, 1991). The new curriculum advocates a focus on fewer major concepts so that material can be explained in depth. The rigid boundaries of the science disciplines is softened, and instruction follows a constructivist approach based on research on how students learn. Science is related to social problems such as health and the environment, as well as the history and nature of
scientific inquiry (Bybee, 1993).

Laboratory has always been considered an integral part of science instruction, but suggestions from the NSES would shift the emphasis from cook-book type labs for verification to those that actually let the students solve problems or find solutions. Students would have access to appropriate resources such as computers. Less time would be spent on book study and vocabulary, and more time on reflection, discussion, and expanded experiences. Working in collaborative groups, students would design and conduct scientific investigations. They would formulate and revise explanations using evidence and logic, then communicate and defend their position and analyze alternate explanations (NRC, 1996). A realistic view of science as a process would be presented, using historical references to let students see how discoveries have been made in the past, and how these discoveries have affected the future (DeBoar, 1991).

Teaching Standard B addresses the issue of how to accomplish the goal of teaching an inquiry based curriculum. Teachers of science guide and facilitate learning by interacting with students to focus and support inquiry (NRC, 1996). This means that learning must be centered on the student. Meaningful learning occurs as a result of personal actions such as active engagement in activities and discussions about ideas and problems with peers. Manipulating equipment, independent work, listening to the teacher in whole class settings, and responding to teacher questioning are also important (Tobin, 1990). Direct hands-on learning is necessary to give students the experiences that are needed to connect new ideas and theories. Pure “discovery learning” is very difficult to accomplish and takes a large amount of time and planning, but simply following directions and observing results does not encourage the development of scientific thinking skills. A “guided discovery” approach where students are led by the teacher to draw meaning from experience is one solution. Science teachers must be educated in many methods of teaching and assessment, and personally participate in inquiry based activities (DeBoar, 1991).

Current research on how the brain learns suggests that teachers need to maintain a state of “relaxed alertness” in students and design appropriate experiences in a well orchestrated environment. Maximum connections in the brain require the relaxed alertness
of a low threat high challenge environment. Students need to process experience in multiple ways, confirm real learning, and sustain the process over time (Caine, 1991). Students need to access their natural memory, the ability to recall the facts of a meal the day before, rather than their short term memory where material is learned by rote and then forgotten (Caine, 1991). The key difference between knowledge and experience is that we acquire knowledge, but we learn by processing experience. Learning should be a personally meaningful and conceptually coherent path to understanding instead of simply memorization (Caine, 1991).

Orchestrated immersion and relaxed alertness alone are not enough. Maximum connections, deeper insight, and additional possibilities must be deliberately and consciously worked on. Students usually lack the skills and necessary awareness to search for deeper implications and teachers must guide students in this process (Caine, 1991). Active processing is the consolidation and internalization of information by the learner. This should be the goal of teaching. Students should answer the questions, “What did I do? Why did I do it?, And what did I learn?” This creates the learning experience previously described by Dewey (Caine, 1991).

As the final step, these changes must be measured. Students’ perceptions can provide a successful basis to guide attempts to improve classroom environments (Burden, 1993). In a study by Kenneth Tobin using the Classroom Environment Scale, students in exemplary classes scored higher in assessing the learning environment than students from comparison classes. This type of quantitative data helps to establish the relationship between nature of classroom environment and science students’ achievement of several inquiry skills and science related attitudes (Tobin, 1990). Teachers can expend a great deal of effort in orchestrating an experience, only to discover students have absorbed very little (Caine, 1991). Brodner states, “... we can teach, and teach well, without having the students learn.” (Vance, 1996). Using tools such as the revised Classroom Learning Environment Survey can allow teachers to measure the success of changes in the classroom, and provide data for further improvement (Taylor, 1995).
METHODOLOGY

In this project an action research approach was taken to study the question of how students’ perception of shared control changes in an inquiry based science program. Teaching standards A and B of the NSES were chosen in this study and applied to two biology classrooms with a total of seventy students, mainly freshmen and sophomore grade level. A modified version of the CLES was used to measure the students’ perceptions of shared control.

An action research format was chosen for this project because it allows the teacher to investigate ways to improve the learning experience in the classroom, and be directly involved in generating and processing data (Feldman et al, 1992). If the NSES is going to make any difference to students in the classroom, the vision of this publication must be utilized by teachers to improve the classroom environment. By becoming researchers in their own classrooms, teachers can address issues that are significant to their situation, and collect data to analyze the effect of any changes that are implemented (Taylor, 1995). This process can contribute to the professional development of teachers as they reflect on their teaching techniques and the response of the students (Kyle, 1997).

In this study one teacher was motivated to change the format of a high school biology course after reading the NSES Teaching Standards A and B. Teaching standard A calls for the planning of an inquiry based science program. The first step in planning was to pick long term objectives. Since the high school where this study was conducted is on a two semester system, with each semester divided into two quarters of approximately nine weeks, the teacher chose to plan the program using four main topic areas. The four topics, one for each quarter, were the characteristics of life, cells and cell processes, genetics, and body systems. This corresponds to the content areas proposed in the NSES standards and Benchmarks for Science Literacy.

Rather than using the present text, BSCS Biology, Blue, as a guide, the teacher chose to use the book as resource. The chapters, or portions of chapters, that related to the
topic were chosen for each quarter. For the first quarter Ch 1-3, 5 and 26 were used as a basis for instruction. Standard A gave the teacher the freedom to break away from the chronological mode of teaching where each chapter would be covered in order. As part of an inquiry based science program, time was devoted each quarter to a project of the student’s choice, relating to the theme of the quarter.

The short term objectives for the first quarter were to give students an understanding of living systems through exploring the needs and characteristics of living things, the classification of living things, and the relationships of living things. After six weeks of instruction on these topics, the students were directed to choose a topic relating to these areas for their project. The project was designed to allow students to integrate science with other subjects or interests. Each student was required to develop a written, oral and visual component for their project, and present it to the class after three weeks of work.

Art, creative writing, and dramatic interpretation were all utilized in student products. Time was devoted to research skills, and two days were spent in the library. An additional day was spent in the computer lab to allow students access to the internet. The students also participated in the formation of the grading rubric, and used the rubric for self-assessment.

Teaching standard B urges teachers to guide and facilitate student learning. This was demonstrated by the process of assigning and developing the student projects. Time was spent in helping students identify their topic, and relate it to the theme of life. Students were encouraged to try different formats for each component of the project, and shown examples of previous student work. Time was spent in brainstorming ideas, and planning how to accomplish those ideas. Each student was required to write a contract stating their topic and intended product for each component.

At various points in the project students were asked to add certain items to the contract. Students made a time line on this contract to show when different tasks would be completed. Before going to the library, students were given a sample bibliography sheet, and practiced writing a bibliography using the text book. After two days of research, the students were instructed on writing an outline for the written portion of their project. Mid way into the project of three weeks, the students helped to formulate a grading rubric, and
added this to the contract as well.

On the assigned due date, the students were given time to self grade their written work and visual aid, using the grading rubric that was designed by the class. The students turned in the written component of the project, and then presented the oral portion using their visual aid. The teacher used the same rubric to grade the complete project, and the students could then compare their grade to the one the teacher had given the project, once it was handed back.

After implementing these changes in the biology classroom, it was important to measure the students’ perceptions of these changes. More specifically, would the students recognize that they had been given some choice and control over their own learning? The Classroom Learning Environment Survey was modified for use in measuring the student’s impression of their learning before and after doing the project. The tool was modified to provide the students with a clearer understanding of the questions, and less repetition of the items.

Five items were used to measure the student’s perceptions of control. Each item focused on an area of a typical unit of material. The first question asked students if there was any shared control over what was learned. The second was on the activities chosen to learn the material. The last three looked at shared control over the amount of time spent on the material, the testing, and grading. The items were scored using a Likert scale, and the students were asked to first score what was actually occurring in the class, then score what the students wanted to occur in class. (Appendix A)

The students were given a pre-survey the second day of school to establish a baseline for future reference. After six weeks of regular instruction, the students were again surveyed, and the results were compared to the pre-survey. At the end of the quarter, the students were administered the survey to provide results that incorporated the experience of doing a project.
FINDINGS

The pre-survey results showed a great deal of consistency in students from varied backgrounds. Twenty-three students were from the eighth grade science program at the middle school, while thirty students were from the integrated lab science program at the high school, a course that is usually taken the freshmen year. Twenty students did not identify a science class or were transfer students. In all cases the average student scores rated the previous science class lower than the wanted conditions. Most students were quite consistent in wanting more control, but not complete control, over their learning, activities, time, tests, and grading. (Figure 1)

FIGURE 1.
Pre-survey Averages

- □ Total average
- ▲ 8th grade average
- ◊ ILS I average
- □ Other average

<table>
<thead>
<tr>
<th></th>
<th>Learn activities</th>
<th>Test</th>
<th>Grade</th>
</tr>
</thead>
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<td></td>
<td></td>
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<td>5.00</td>
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<tr>
<td>Sometimes</td>
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<tr>
<td>Never</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

actual | want
After six weeks of regular instruction the survey was administered again. The results of the want categories were very consistent with the pre-survey results, indicating a high validity with the tool. The course work in biology up to this point was almost totally teacher directed, with very little opportunity for the students to make choices in the topics they wanted to study or the activities they wanted to do. The want items actually rose a small amount for the areas of activities, time, tests, and grades. (Figure 2)

FIGURE 2.

After Six Weeks

<table>
<thead>
<tr>
<th>Always</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sometimes</td>
<td>4</td>
</tr>
<tr>
<td>Never</td>
<td>3</td>
</tr>
<tr>
<td>1 1 1 1 1</td>
<td>1 1 1 1 1</td>
</tr>
<tr>
<td>learn</td>
<td>activities</td>
</tr>
<tr>
<td>actual</td>
<td>want</td>
</tr>
</tbody>
</table>

The survey was administered a final time at the end of the quarter. At this point the students had completed the individual project and given their presentations. The results did not indicate much difference in the students’ perceptions of shared control when the data was averaged together. (Figure 3)

The results were then compared on an individual student basis. Here there were significant differences in individual scores from the final and intermediate surveys. Some students showed a positive change in the actual categories after the project, while others
reported a negative change. A follow up questionnaire was given asking the students to reflect on the survey. Many students indicated that they had not thought of the project as anything different. (Table 1) They were more interested in being given choices in the regular practice of the classroom. Suggestions such as voting on which class activities to do, or being allowed to choose activities from a list were common. Some students also indicated that they did not want control in areas such as grading, considering that the job of the teacher. (Appendix B)

**FIGURE 3.**
Comparison of Surveys

- □ End of Quarter average
- ○ 6 weeks average
- ■ Pre-survey average

<table>
<thead>
<tr>
<th></th>
<th>learn activities</th>
<th>time</th>
<th>test</th>
<th>grade</th>
<th>learn activities</th>
<th>time</th>
<th>test</th>
<th>grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>actual</td>
<td></td>
<td></td>
<td></td>
<td>want</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Sometimes</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Never</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**TABLE 1.**
Individual Analysis

<table>
<thead>
<tr>
<th>Change in response from intermediate survey to final survey.</th>
<th>Did the project influence your responses in the survey?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Change 30 responses</td>
<td>16 yes</td>
</tr>
<tr>
<td>Negative Change 30 responses</td>
<td>12 yes</td>
</tr>
</tbody>
</table>
In continuing to analyze the students' impressions, another questionnaire was given about the project itself. The students responded with their own written statements in various areas. In this type of format, many of the students responded that they had enjoyed the project and felt that they were given control. The majority of the students responded positively to the project, and indicated that they learned from the experience. (Appendix C)
IMPLICATIONS

In this study, the independent project that was integrated into the biology course was a relatively small change in the curriculum, but it did provide the students with a chance to explore a topic of their own choosing. Many of the skills emphasized were interdisciplinary in nature, such as library research, and speaking skills, but most of the students did not investigate their topic in much depth. Was the project experience actually worth the time and effort? The survey results did not seem to indicate that the students as a whole felt it made a difference in the area of shared control, but the short answer questions did show that most of the students enjoyed doing the project. Was this truly fulfilling teaching standards A and B of the NSES?

The implications of the results of this study fall into three areas: The usefulness of the NSES in effecting change, the validity of action research in the classroom, and the ability to measure student response to changes in a meaningful way.

With the publication of the results of the Third International Mathematics and Science Study (TIMSS), and the interpretation of Pursuing Excellence, the need for national standards in Mathematics and Science has been pushed to the forefront of the educational agenda of this country. The first point of President Clinton’s Call to Action for American Education in the 21st Century is to set rigorous national standards. The National Science Teachers Association also advocates the use of the National Science Education Standards as a “common vision of science education reached by consensus of teachers, administrators, scientists, and policy makers”. (NSTA, 1996)

How do these views affect the regular classroom teacher? Trying to apply the standards to a classroom can be an overwhelming process as there are many standards in many areas, from teaching, to content, to assessment. There are also multiple documents. The teacher in this study chose to use the NSES teaching standards, but the AAAS has published Benchmarks for Science Literacy, which contains 60 “literacy goals” and the NSTA produced The Scope, Sequence, and Coordination of National Science Education
Content Standards. (Marzano and Kendall, 1997) There is a great need for materials that will assist the classroom teacher in utilizing and applying these documents to the classroom.

In this study one teacher interpreted the NSES in a way that changed the teaching practices and course requirements for a high school biology course. Another teacher could apply these same standards with very different results. Obviously, the standards must be general enough to encompass the many different situations that arise in a country as large and diverse as the United States. But it would be very helpful to have some guidelines or examples to work from in applying these standards to the classroom.

Of course, any change in curriculum must also be acceptable to the school district it will be taught in. A recent study at George Washington University provided teachers with the opportunity to work together to create units that would exemplify the goals of the standards. These units focused on a central problem for students to solve and were interdisciplinary and activity based. Unfortunately, many of the teachers did not actually use the units in their classrooms because the material did not follow district guidelines or fit the criteria for “getting students ready for college” (Lynch, 1997).

Introducing changes into the classroom is an area that needs examination. In this study, one teacher was motivated to read, think about, and apply the NSES to the classroom as part of the requirements to complete a masters program. To implement change, there usually needs to be some sort of motivation. Many teachers are willing to change practices to help the students, but there is usually no motivating factor large enough to overcome the burden of extra work. Agencies such as the universities, school districts, and state and federal governments need to find ways to get teachers involved in becoming aware of the NSES, and ways to use them in the classroom that will fulfill existing requirements, and change student learning in a positive way.

One way is to encourage teachers to do research. Action research can be an important tool in teacher development (Kyle, 1997). Implementing changes, and measuring the results can be an informative, and exciting part of teaching in the classroom. The results of action research can provide the teacher with a better understanding of the
students, and how they perceive changes in the classroom. One purpose of the NSES is to
guide teachers in designing curriculum, and a natural outcome of this process is to check
for student impressions of the changes.

Teachers need to be encouraged to explore action research, and given the time and
resources to accomplish it. What would happen if school districts would encourage and
present opportunities for research? Would more teachers be willing to try if the principal of
the school was interested in the project? Many teachers are already overwhelmed by the
time and effort they put into the regular teaching schedule. How could more time be made
available? If the NSES are going to make a difference, the classroom teachers must be the
ones to actually implement the changes, and they must be encouraged, and motivated, to do
so.

The effect of these changes on student perceptions must also be part of any process
that intends to improve education. Many ideas sound good on paper and are easily
implemented, but make no impression on what the student actually does or thinks.
Measuring student response requires some effort on the part of the teacher, and is not
always easy to interpret, but it is a vital part of the reform process. Tools that allow
teachers to assess the students and their impressions must be made available.

In this study, the Classroom Learning Environment Survey (CLES) was modified
to provide the teacher with a survey that was easy to use. The collected data was
interpreted with a spreadsheet program on computer. This allowed the teacher to easily
manipulate the data and make graphs using different parameters. Both of these tools were
made available because the teacher was working on a masters degree and had access to
classes and materials at the university. Teachers must be given the training and tools
necessary to carry out these processes if changes are to be measured. Again, local
encouragement and support from their own school district and site administrators could be
an important key in involving more teachers in this process.

Unfortunately in this study, the data collected using the modified CLES did not
give results that pointed to any change noticed by the students when averaging the class
responses together. This led the teacher to try a more open response type of survey, where
the students had to write down their impressions. The information provided by the short answer style survey was more informative, and did indicate a positive student response, but this was also harder to tabulate and average. This data could not be compressed into nice neat graphs, and it was very time consuming to read and record the responses. Most teachers, when faced with grading papers, tests, and other tasks, would not choose to spend so much time on this material.

The individual analysis of the CLES data did indicate that some students had a positive response to the project, while others did not. A negative response actually could indicate that the student was affected by the project, but may not have liked the task of choosing a topic, or doing something different that disrupted the normal classroom routine. Obviously, not all students will respond to new ideas in a positive manner, and this could relate to areas such as internal and external motivation. Action research in areas such as the relationship of internal motivation and response to change could give valuable information to teachers as they work to provide a better science education for students. As educators work to integrate the ideas of the NSES into the classroom, many more questions for study will arise.

Teachers face many problems in implementing the standards. First of all, curriculum material aligned to the standards must be developed. This is a time consuming process that is difficult to accomplish while teaching. The material must also be acceptable to the school district, parents, and students, as they prepare for college or other goals. A second problem teachers face in this endeavor is analyzing the changes to decide if they meet the goals of the standards, and affect the students’ learning for the better. Action research can provide teachers with the opportunity to explore these areas, but teachers must be given time and incentive to do this. Thirdly, teachers must be given the tools and techniques necessary to analyze and interpret data that is collected from the research, and a meaningful way to present it.

Will National Science Education Standards make a difference? In this study the standards did affect the teaching practices of one teacher, and the impressions of some of the students. What long term, widespread effects the standards will have remains to be
implemented, measured, and analyzed by many more teachers. The next important step is to motivate and encourage them in this effort.
APPENDIX A
Modified Survey

Answer the questions based on your previous science class(es)

<table>
<thead>
<tr>
<th>I helped the teacher decide:</th>
<th>almost never</th>
<th>seldom</th>
<th>some always</th>
<th>often</th>
<th>almost always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. what I learn</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. which activities I did</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. how much time I spent on activities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. how I am tested on what I learn</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. how I am graded on what I learn</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Answer the next questions based on what you would like in this science class

<table>
<thead>
<tr>
<th>I want to help the teacher decide:</th>
<th>almost never</th>
<th>seldom</th>
<th>some always</th>
<th>often</th>
<th>almost always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. what I learn</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. which activities I did</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. how much time I spent on activities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. how I am tested on what I learn</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. how I am graded on what I learn</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
APPENDIX B

Questions About The Survey Responses

1. Did the 1st quarter project influence your responses to the latest survey? Why or why not?

   29 Yes
   22 No
   14 blank

2. Describe how each of the following could be accomplished in this classroom:

   A. helping the teacher decide what I learn

      34 - give choices
      8 - teacher should teach stuff students need to know for next class or college
      ask students what format they learn best in
      teach at a more advanced level
      we don’t know enough about biology to choose what we learn

   B. helping the teacher decide which activities I do

      27 - allow students to have input through voting or class discussion
      16 - choose off a list
      6 - if students think it is fun, they will get more into it
      don’t want to help decide
      up to the teacher

   C. helping the teacher decide how much time I spend on activities

      42 - not enough time, let students help decide

   D. helping the teacher decide how I am tested on what I learn

      13 - review
      16 - give students a few options
      11 - teacher should make the test, they know best - 11
      3 - make up a test and take a few questions from each paper (but sometimes hurts more than it helps)

   E. helping the teacher decide how I am graded on what I learn

      24 - make a grading scale
      12 - the grading is not up to the student
      4 - less percentage on tests because some students are not good test takers
      graded on what we do, not how we do it
      we should help decide
      it would be too tempting to make it easy on myself and not learn anything
3. Describe anything that is confusing or difficult to understand in the survey
   27 - nothing
   15 - various items
APPENDIX C
Reflection Sheet Responses

1. I liked doing this project because:
   34 - I was interested in my topic, and chose it
   26 - I learned something
   2 - no reason

2. I did not like doing this project because:
   20 - it took extra time or too much time
   9 - it was hard to find information
   4 - I liked doing my project
       it was a lot of work, but I wanted to do it

3. The best thing about my project was:
   18 - my visual aid
   11 - my written report
   9 - my pictures
   8 - it was interesting
       it was unique, creative, wonderful
       it was fun
       it was easy

4. The best part of the oral report was:
   14 - I could hear about other projects
   11 - it was short
   10 - I could show/share knowledge
   6 - it was interesting
   5 - I learned new information
   2 - nothing

5. I could improve my project by:
   23 - making a better visual aid
   11 - working grammar, spelling, and punctuation
7 - writing more
5 - it was already perfect - 5
4 - typing it (one student said she had no computer)
3 - putting in more time and effort
REFERENCES


