Evaluating the Long Term Effect of Teacher Enhancement

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TABLE OF CONTENTS

I. INTRODUCTION

Although the ultimate goal of teacher enhance projects is to improve student outcomes, the causal path from teacher enhancement projects to changes in student outcomes is difficult to verify. Therefore this evaluation was designed to examine the long term effects of a teacher enhancement project on classroom activities and student outcomes at five different schools through case studies. The longitudinal approach is necessary to determine not only what happens initially but what remains after the funding and "newness" wears off. The enhancement effort was part of the Scope, Sequence and Coordination Project (SS&C) and consisted of two summer workshops, during the year contact, and curricular materials matched to the instructional philosophy presented at the workshops. The measure of persistence is the effect of the teacher enhancement on the schools, as demonstrated by teacher classroom performance and achievement of ninth grade students year after year.

This report presents information gathered over four years, 1995-1998, from the five teacher enhancement sites. It is the first report under the "Evaluating the Long Term Effects of Teacher Enhancement" grant and the fourth in a series of evaluation reports about the Scope, Sequence and Coordination Project. The interested reader is directed to peruse the prior reports on the web site at carei.coled.umn.edu. This report begins with a section on the history of SS&C followed by a detailed description of the data collection procedures. This background information is followed by a presentation of consolidated impressions garnered from the five case studies. These overall comments are followed by the individual case study reports.

II. HISTORY

The Scope Sequence and Coordination Project was developed by Bill Aldridge who was the executive director of the National Science Teachers Association until1997. The project was formed out of the concern for the US's leadership in science and mathematics

prompted by the international comparisons of student performance in mathematics and science. Bill Aldridge's vision of how to make U.S. students the "first in the world" was to have them study every science every year rather than one science for one year followed by study of another science. The vision was embodied in the title of Scope, Sequence and Coordination. Scope meant that the studies should be rigorous. Sequence meant that the students should have experiences first and then tie these experiences to concepts, and coordination meant that each science was to be coordinated with the others not presented one at a time. The first operationalization of Aldridge's vision was a middle school project where students studied all sciences in a coordinated fashion each year they were in middle school. This middle school SS&C project was conducted at several sites throughout the U.S. Although each site could point to several accomplishments, there was little that tied them all together. Each site had implemented SS&C in its own unique way.

This led to the second operationalization of Aldridge's vision; a high school based SS&C project. This project was headed by Aldridge and controlled centrally with all sites doing the same things. The goal of the project was to improve student performance on the newly developed National Science Standards (NRC, 1995). Furthermore the project was based on 10 tenets of SS&C:

1. To provide science learning in four subject areas each year: biology, chemistry, physics, and the earth/space sciences;
2. To explicitly take into account students' prior knowledge and experience, as expressed in their preconceptions and metaphors (much of this is available in the literature);
3. To provide a sequence of content, and the learning of it, from concrete experience and descriptive expression to abstract symbolism and quantitative expression;
4. To provide concrete experience with science phenomena before the use of terminology that describes or represents those phenomena;

5. To revisit concepts, principles, and theories at successively higher levels of abstraction;

6. To coordinate the four science subjects so as to interrelate basic concepts and principles;

7. To utilize the short-term motivational power of relevance by connecting the science learned to subject areas outside of science (such as history, art, and music), to the practical applications of how devices in our technology work, and to the challenge of solving those personal and societal problems that have relevant underlying scientific components;

8. To utilize the long-term motivational power of sudden and profound understandings of science and of the awe which stems from comprehension of the power and universality of a relatively small number of fundamental principals of science;

9. To greatly reduce topical coverage, with an increased emphasis on greater depth of understanding of those fewer fundamental topics;

10. To create assessment methods, items, and instruments to measure student skills, knowledge, understandings, and attitudes, both for program evaluation and the requirement of assigning grades, which are fully consistent with tenets 1-9.

The project was designed to provide teacher enhancement and curricular materials through national workshops and committees. During the first year of the project the teachers were to be developing, pilot testing and revising lessons that fit the 10 tenets of SS&C. These lessons were to serve as a basis for an intensive summer workshop where the teachers would be steeped in the SS&C philosophy and work as a development team in the finalization of the draft grade 9 SS&C curriculum. The idea was that this involvement in the development process would allow the teachers to construct their own meanings of the SS&C philosophy so that they would "own" it when they returned to their classrooms. Teachers were also members of various national committees, e.g., assessment, where they worked on specific ideas to be shared with the whole group. The

plan was that the next year and summer would focus on the development of grade 10, the next on grade 11 and finally in the fourth year, grade 12.

There were 13 schools participating in the project originally. Two in North Carolina, 3 in Texas, 3 in California, 2 in Iowa and one each in MT, NY and Washington, DC. Several of the states CA, IA, TX, and NC, had participated in the middle school project and so were familiar with the philosophy of SS&C and had some infrastructures in place for support of the teachers. In these states local liaisons, generally affiliated with a local university, provided guidance to the teachers in the schools and offered workshops throughout the school year to further the teacher enhancement.

The project had a comprehensive evaluation component. The evaluation was designed to be summative in nature. The evaluation used a time lag, quasi-experimental design where the students in each school during the first year served as the comparison group for students in the subsequent years. The comparison group was 1994-95 school year students in the same schools as those students whose teachers received the SS&C teacher enhancement and materials. In this way most of the contextual variables were controlled. The evaluation gathered data on three major outcomes: student achievement, student attitude and motivation for science, and classroom activities. Evaluation team members monitored classroom activities through observations, student and teacher questionnaire data and interviews with teachers and students. Student attitude and motivation were measured through questionnaire data. Student achievement was measured through the use of several different types of assessments. Students completed multiple choice items, open-ended items, laboratory stations and experiments.

After the first year and half, the continuation of the project was being questioned. There were concerns about the cost of the project, the quality of the curricular materials and the ability to move the project into the 11^{th} and 12^{th} grades. There was no official word on continuation of funding until after the second summer workshop, so that workshop continued as planned. The purpose of the second summer workshop was to provide

opportunity for enhancement for the grade 10 SS&C teachers. This included some of the teachers who had participated in the grade 9 instruction and enhancement as well as new teachers. After the summer workshop the project received word that it had not been funded to continue development into the 11th and 12th grades. There were some funds left to finish out the school year but after that the project would have to continue through the efforts of the individual schools. This was quite a blow to the participating schools, although since the school year was beginning and the curricular materials were ready, they went ahead with offering the grade 10 SS&C.

The evaluation continued mostly as planned and by the end of that year had three sets of data: grade 9 student data from the comparison year (1994-5), grade 9 student data from the first year of the project (1995-6), grade 10 comparison student data (1995-6), grade 10 SS&C student data (1996-7) and grade 9 student data from the second year of the project (1996-7). The data had shown that overall the students participating in SS&C were no worse in terms of achievement than the comparison students and that the SS&C classrooms were considerably more student centered and inquiry based. There were slight indications of a positive effect of SS&C on student laboratory skills and attitudes toward science.

There were also indications that the national teacher enhancement effort had been mediated by school effects. In other words the results for each school were somewhat unique. This led the evaluation team to propose a second project that would examine these effects in a longitudinal and more process oriented fashion, "Evaluating the long term effects of teacher enhancement." This project proposed monitoring the effects of the teacher enhancement efforts at five of the original 13 sites. The same comprehensive data collection would be continued and would be augmented by more in-depth interviews and more questions about the enhancement process. The five sites became case studies in which the interaction of the national teacher enhancement effort and local forces would be documented and the effects on student and classroom outcomes would be tracked.

III. DATA COLLECTION AND ANALYSIS

The evaluation used a post-test only, comparison design. In this design, science classes from the year prior to implementing SS&C were compared to subsequent science classes during the 1995-96, 1996-97, and 1997-98 school years. In essence, it was a time-lag design where the first year's 9th grade science classes were compared to the second, third and fourth year's 9th grade science classes.

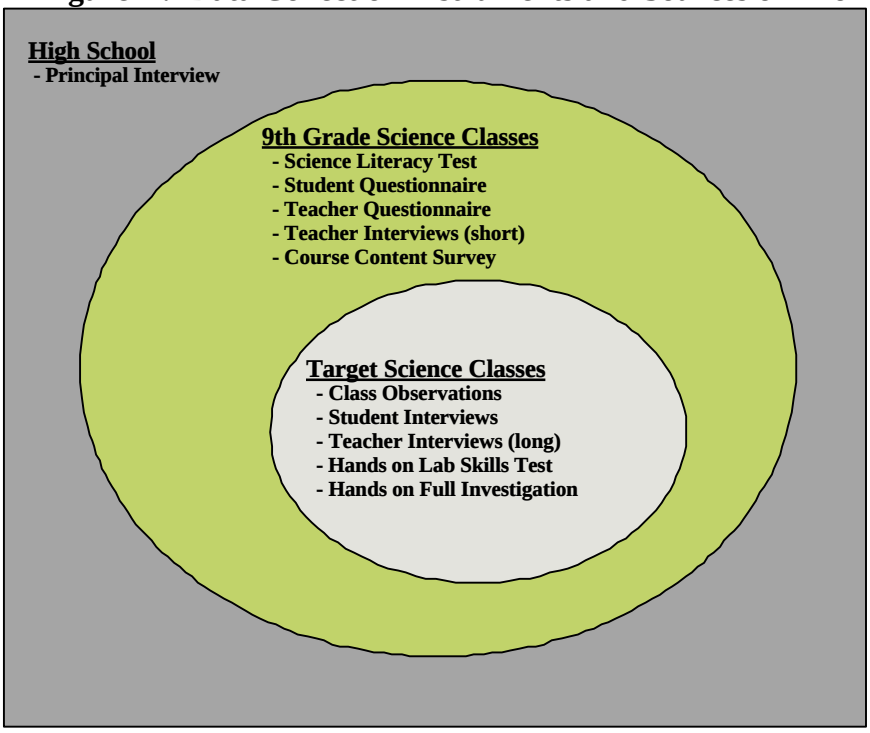
Five high schools were included in the evaluation. The schools were chosen from the thirteen schools involved in the original evaluation of SS&C. They were selected to be representative of the diversity in the US in terms of geographic areas, population and race/ethnicity. The schools were located in Texas; California; Iowa, Montana; and New York. There were approximately 20 teachers teaching 9th grade science classes at these schools and over 2,000 students being taught by these teachers each year. Ninth grade science courses at these schools during the 1994-95 comparison school year were quite diverse; some courses concentrated on a single science area such as physical science, life science or earth and space science, while other courses included various arrangements of the sciences such as integrated and coordinated science; some courses were a year long and met everyday for 45 minutes, while other courses were only a semester long and met 90 minutes each day.

A nested data collection design was used to gather information at each of the school sites using ten instruments developed by the evaluation team. Contextual variables were assessed using a classroom observation schedule, principal, teacher and student interview protocols, a teacher questionnaire, a student questionnaire, and a course content survey. Because the major measure of the effectiveness of the SS&C project was student achievement, it was examined from several different perspectives. Students answered multiple choice and open ended science content items, participated in a five station hands-on laboratory skills test and designed and conducted an experiment. Standardized administration and scoring protocols were developed to ensure consistency and

objectivity. Descriptions of all assessment instruments, the instrument development process, and the psychometric properties of the instruments are included in the Appendix.

At each school data were collected from all participating ninth grade students and teachers. In addition three ninth grade classes at each school were targeted for more comprehensive data collection. Except for the science literacy test and the course content survey which were mailed to the schools near the end of the school year, the data were collected by the evaluation team during site visits. During the fall and spring visits, all ninth grade teachers were interviewed and the three target classes were observed. During the spring visit in addition to the interviews and observations, most of the ninth grade students were given a questionnaire to complete. Those not taking the questionnaire were 6-12 of the students in each target class who were randomly selected to take the performance tests. One student from each target class was also interviewed. The school principal was interviewed only during the fall site visit. See Figure A for a schematic of the data collection instruments and sources of information.

▲ Figure A: Data Collection Instruments and Sources of Information



The results of the tests and questionnaires were analyzed using the students as the unit of analysis. In previous evaluation reports, the class was used as the unit of analysis because data from all 13 schools were combined and there were over 100 classes in the evaluation. In the present study, we are using a case study approach and the data from each school are not being combined. We do not have enough classes at each school to justify analyzing the data by class, and therefore the data were all analyzed using the student as the unit of analysis.

IV. CONSOLIDATED IMPRESSIONS

Case studies are not designed to be consolidated quantitatively. They are unique descriptions of a particular set of circumstances. The evaluation team has built up an in-depth understanding of the sites. We have worked with them for the past four years visiting them once in the fall and once in the spring. The team has included the same three site visitors over the four years and the three visitors have extensively discussed the sites among themselves. We recognize the diversity of the sites and understand that generalizations could be misleading. Within these parameters, however, we believe some general impressions can be formed.

Because it is difficult to understand generalizations without any knowledge of the individual entities, capsule descriptions of each of the five sites are provided. These are grouped into those who retained most of the SS&C activities and philosophy and those who only retained some of the SS&C activities and philosophy.

Sites retaining SS&C activities and philosophy

1. A small group of 9th grade teachers attended the national training and were personally responsible for the 9th grade curriculum. No new teachers were required to teach the curriculum until after several years and it had been well established. The teachers were committed to the new philosophy and believed it would improve their teaching. They were supported by an outside (non 9th grade) SS&C liaison person who

facilitated their implementation of the course and its philosophy and encouraged the teachers. The school had the necessary facilities and materials for the course and had few behavior or discipline problems. All 9th graders (except a small group of honors students) participated in the curriculum.

2. Several teachers were responsible for the teaching of 9th grade science. Different subsets of these teachers attended the national training. The teachers felt that their old methods of teaching were not "reaching" the students and they believed SS&C would be the answer. They worked as a group to develop the specific lessons for their school and met often to keep everything organized. They had a liaison teacher who taught 9th grade sometimes and who supported their efforts but he was not a "power broker" or a "leader". New teachers were supported by the team. The school facilities were not always adequate but the team made modifications as necessary. All 9th grade students participated in the curriculum. The student body was quite diverse but more apathetic than problematic. In order to better match a state wide testing program, the 9th grade curriculum was modified to include more physical science than originally intended.

3. A small group of teachers were responsible for the teaching of 9th grade science and they were the ones that make the decisions about what and how to teach. They were experienced teachers and believed they were doing well, but were willing to give the new philosophy and methods a chance, in order to give their students a better and more diversified science experience in grade 9. They all attended the national training. The initial liaison teacher retired after the first year of SS&C implementation and was replaced by the most senior science teacher in the department. The current liaison teacher attended the national workshops and also strongly supports the continued implementation of the 9th grade curriculum, which has been internally modified and revamped to better fit what the teachers believe is necessary for their students. All 9th graders (except a small group of honors students)

participated in the curriculum. The school had the necessary facilities and administration support and few behavior or discipline problems.

Schools retaining some SS&C philosophy or curriculum

4. There was a small group of experienced teachers who attended the national training and some others who attended local training. Because of teacher turnover, a large group of teachers taught 9th grade. The new teachers were encouraged to teach using SS&C philosophy and lessons by the liaison teacher but the liaison teacher did not teach 9th grade. Individual teachers had significant control over what they taught in their 9th grade classes and those that did not attend the national training were not as skilled in, nor as committed to, implementing the SS&C philosophy. With the retirement of the original liaison teacher, a major impetus for the philosophy and materials was lost. The school did not have adequate facilities to support the course. The two teachers who attended the national training still teach somewhat in accordance with the SS&C philosophy. The state mandated a new course for 9th grade, so the SS&C curriculum will not be used although some of the SS&C activities that fit into the new course will be.

5. There were two groups of teachers who attended the national training and a large group of teachers involved in teaching the 9th grade SS&C course. The teachers in the school were already committed to a hands-on, inquiry approach to science so the SS&C philosophy matched theirs. The main difference was the notion of covering all sciences in the course. The liaison teacher was "in charge" and significantly encouraged the teachers to implement the program. The other teachers did not all agree with SS&C—mostly because they believed they had been teaching well before the program and saw no reason to change. The school was very well equipped to support the program. The state mandated a new course for 9th graders, so the SS&C curriculum will not be used. The teachers retain their hands-on, inquiry approach to science.

Probably the most important impression is that the schools are indeed unique communities. There are, of course, some general similarities but each has its own personality, its own processes and its own goals. Recognizing this inherent individuality, it may be that for any external teacher enhancement effort to be successful, it must fit within the constraints of the school. At the least it appears that the extent of any external effort will be highly mediated by the environment of the school. It also suggests that any quantitative analyses of teacher enhancement efforts use the school as the basis of comparison or employ HLM techniques.

Part of the uniqueness of the school environment is the leadership or power structure that exists within it. All of these sites had different power structures and having the support of the power structure was critical to the implementation of change. It appears that the most successful structure for ensuring implementation of the enhancement is one in which leadership is shared. This structure is one in which all (or most) of the players are involved in the decision making about how and what to teach and all reach consensus. It is then that the changes appear to be more lasting. For example, two of the sites had teams of teachers working on the grade 9 curriculum and teaching methods. Subsets of them had received the enhancement but in interacting with their colleagues they made it their own. The commitment to 'what works with our students in our schools' and the teachers' beliefs that they were doing the best for their students appears to foster continued participation.

A second successful power structure is when there is only a small subset of teachers with the power and authority to bring about change. One of the sites had two teachers working consistently on the reform and both had participated in the national enhancement. These teachers worked together in ways similar to the first examples but were on board from the start and did not have to deal with bringing new teachers into the loop. In other words all of the players were also involved in this power structure but the number of players was very small and therefore it was easy to involve everyone.

A power structure that was less successful in the long term was when most of the power was held by one individual. This type of individual would encourage the others to participate and would put a great deal of personal energy into making sure the project worked. Two of the sites had this sort of top down power structure. This structure worked well in the first years, but then as the power structures evolved and different teachers moved into power, the change reverted.

Another element affecting the implementation and longevity of change is the culture of the school. It appears that the teacher enhancement was more effective in schools where the teachers felt the need for change. Desire for change or dissatisfaction with the existing curriculum undergirded the efforts of teachers at several sites. At one site the teachers felt they were not "reaching" their students with traditional methods and they believed the new SS&C philosophy would help them to do so. This initial belief was reinforced by the students' reactions in the first year and led to a more dedicated effort to employ the philosophy in subsequent years. Another site was disenchanted with their present material and wanted to change. SS&C came along at the right time for them. At two other sites there was resistance to change, the teachers felt they were doing a good job already and that they were good teachers. Changing meant admitting that what they had been doing in the past was not as good as it should have been. At one of these sites the teachers believed that the new teaching styles were helping the students to understand more and so they kept trying to implement the changes even though they did not initially believe in them. At the second site the teachers went back to their more traditional styles, although some modifications were maintained by the newer less well established teachers.

A third element that appears to have a significant effect on the science curriculum is the external pressures on the school. In three of the sites, statewide requirements profoundly affected the implementation effort. One of the sites will drop SS&C because the state mandated a different grade 9 course. Even though the course will no longer contain all of

the sciences, it appears that some of the teaching philosophy that is part of SS&C may stay as part of the new course. At another site changing state requirements for graduation predicated a change in the grade 9 course. This course again has retained some of the SS&C philosophy. At the third site the state implemented an assessment that is at odds with the goals of SS&C. Already because the students did not do well on the state assessment, the grade 9 SS&C course was modified to include more physical science in order to better match the test.

Despite the different elements affecting the teacher enhancement efforts at the schools, the project appears to have made a significant impact on the classroom. The philosophy of SS&C, like that of the national standards, is one that calls for student centered learning communities where students design and conduct their own investigations. All of the sites showed significant changes in the types of activities used in science classrooms. The sites became much more student centered in their instruction focusing on hands-on activities, group work, experimentation and the presentation of data or activity before the introduction of terms or concepts—precisely what the enhancement called for.

It appears that significant changes in student levels of achievement are difficult to obtain and that changes in achievement can vary by site. Despite the substantial changes in the classrooms, the students did not consistently achieve at higher levels. There is some indication that increased achievement followed increases in student centeredness but it is inconsistent. Most of the achievement changes were related to hands-on lab skills and designing and conducting experiments, which one would expect given the hands-on nature of the curriculum. Teachers at several of the sites believe students who have taken SS&C are better prepared to conduct inquiry science. Our interviews with individual teachers indicate differing conceptions of the SS&C philosophy. This is corroborated by the classroom observations where some teachers are more “standards based” than others. It may be that the school is still too coarse a basis of measurement and we need to look at individual teachers. This, however, raises the notions of teacher effect and bias.

Overall it appears that the teacher enhancement project was successful in causing changes in the way science is taught. Not only are different teaching styles apparent but many of the teachers appear to have changed their philosophies toward the teaching of science. Classrooms became more hands-on, student centered and inquiry based. The teacher enhancement effort provided by SS&C appears to have worked as a catalyst that instigated the change toward more inquiry methods. The initial appearance and persistence of these changes, however, are dependent on the different elements present in the schools, in other words, the local support provided for the institutionalization of the new SS&C philosophy. It is clear that some sites and individual teachers gained and are retaining more from the enhancement effort than others. The institutionalization of change in a school appears to be greatly affected by external pressures, the power structure within the school and the desire of the teachers for change. A final caveat to keep in mind is that any changes may not be due solely to the implementation effort, since the SS&C philosophy fits well with the National Standards for science which have been receiving a lot of attention.

V. The New York Experience

School Setting

New York High School is in a lovely setting with extensive grounds including a pond and surrounding hills and trees. The site houses both the middle school and the high school. The high school building is adequate and generally clean but not classy, new or "tip-top". Stairs have broken edges, doors are worn, connections between buildings have a long term temporary feel, etc. Science classrooms, however, are full of materials, posters, equipment, projects, etc. Science is always in laboratory equipped rooms either with an older fashioned chemistry type laboratory in the rear of the room (rows of lab stations with gas and overhead storage with water at each end) or flat laboratory tables around the edges of the room with desks in the middle. All are well equipped with materials, gas, water, burners, etc. There are also supply rooms for larger equipment and chemicals and separate teacher office space. The office space is a room on the third floor with desks for each of the teachers. There are also classroom preparation rooms between some of the classrooms that also serve as teacher office/discussion space. Teachers tend to spend their spare time in their classrooms or the prep space.

The community is mixed with very high income homes and very low income housing developments. The low income segment of the community is growing fast. Most of the low income group is Latino/Hispanic. There is also a stable, long term resident population of African Americans. Most of the people work in New York City. The school is well supported by both parents and businesses in the community.

Science Program

The school is in the State of New York which has a system of New York State Board of Regents courses. These courses are rigorous with content specified by the Board for science courses across the State. In 1994-1998 students needed at least one science course—not necessarily a Regents science course order to receive a high school diploma in the State. If the science course were not a Regents course, the students had to take a

qualifying science test. Freshmen beginning in the 1999-00 school year are required to take at least one Regents science course to graduate.

Because of the Regents' course programs, SS&C is only available to a limited number of students at the high school, approximately 60 students per year. These are the students who do not enroll in the NY Regents courses—those who are ESL, those with low levels of motivation or those who are academically challenged in other ways. The classes over the years have been kept small (e.g., 15 students) so that individual attention can be provided. All science classes are 50 minutes per day with two extra periods a week for laboratory experiences. In 1996-97 and 1997-98 the non Regents students could continue into SS&C in grade 10 and in all years into chemistry and physics "topics" (non Regents') classes in grades 11 and 12.

Other grade 9 science classes include Regents earth science and Regents biology. There are two teachers teaching the earth science for a total of four classes with about 100 students or 25 students per class. There are also two teachers teaching Regents biology but there are only two classes offered with about 26 students per class or 50 students. The grade 9 students in Regents biology are the top students academically.

There have been approximately ten teachers in the science department over the data collection years. The teachers rotate through teaching grade 9 science so a different set of 1 to 4 teachers was involved each year. They all have specialty areas like chemistry, physics or biology and many are certified in more than one area. Classes offered include Regents' chemistry, physics, earth science, biology and environmental science; AP biology, chemistry and physics; and non-Regents courses in chemistry, physics, biology and SS&C. The teaching load alternates between four classes one year and three classes the next year.

School Climate

The school is a very student centered environment with the teachers frequently working with students after school and calling parents. The superintendent and the principal believe strongly in high standards and equity. There is a strict attendance policy and students are expected to make up missed work. There is a "you need to work hard, but you will succeed" atmosphere. There is every attempt to help "at risk" students through a variety of special programs.

The State of New York has a very top down, accountability oriented approach to education. The Regents exams dictate much of the curriculum and the exams reflect the Regents' perspectives. The high school fits into this benevolent dictatorship model. The superintendent of the district is closely involved in practical decisions such as the hiring of teachers and his philosophy permeates the schools. Fortunately he appears to be well informed and committed to excellence. The principal at the high school is also very dynamic and hands-on. He believes strongly in high standards and in including all students. He is supportive of the science program (He is a former physics teacher.) and of SS&C. His support of SS&C stems mostly from his belief that it would become a science program for all students rather than a special offering for a few.

Science Department Climate

The science department chair has been involved in a national science curriculum development project which is very standards based and inquiry oriented. The department mostly reflects this approach to science education, since the chair is involved in hiring and mentoring the teachers. Not all of the teachers are supportive of his very inquiry oriented style. Several teachers are entertaining lecturers and believe that the students learn more if they are told something carefully and in an interesting, relevant manner.

The science teaching staff is excellent. The teachers are skillful and work hard to make their classes relevant, motivating and challenging to their students. They are all teaching in the fields of their certification and are well supported. There is money for equipment,

technology and materials, there is a laboratory assistant and their time schedules are arranged to allow for interaction between the teachers and so that they have some time available for longer term planning. They spend a good deal of time working with individual students after school or during class sessions to help them "catch up" or understand concepts they are having difficulty with. There is a high level of concern and interest in the students as individuals and a real desire to help everyone succeed. They are creative in terms of developing new experiments or activities to demonstrate concepts and in developing courses (e.g., biomedical ethics, environmental studies) or extra experiences (e.g., geological field trips).

Overall the science teachers are committed to hands-on instruction with active student involvement. Even the more "lecture oriented" teachers provide their students laboratory experiences; it is just that the experiences are more proscribed than inquiry oriented. There is a strong emphasis on problem solving in the classes although, perhaps because of the Regents' exams, memorization of specific content is also stressed in most classes.

Curriculum, Instruction and Assessment

The ninth grade science experience has varied over the years. The year before SS&C was implemented the students were in three different sections but all taught by the same teacher. The students stayed in the class for the entire year. The course was mostly earth science although all science topics were touched on during the end of the course in preparation for the State examination. During the first year of the SS&C implementation, the curriculum was taught by a team of four teachers, one from each of the science areas. The team taught four sections of SS&C. The SS&C activities were organized into themes such as energy and these themes were carried out in each subject area. For the 1995-7 school years the teachers rotated every two weeks within a theme like energy (2 weeks biology, 2 weeks chemistry, 2 weeks physics, and 2 weeks earth science). However, the teachers felt that changing that often caused them to lose rapport with their students. Therefore for the 1997-8 year the teachers changed quarterly instead. Therefore they taught earth science, biology, chemistry or physics for 10 weeks and covered all the

themes within that time frame. Although the teachers teach only in their areas of certification, that may not be the science area they had routinely taught in the past. For example, a teacher who generally teaches earth science may also be certified in biology and therefore eligible to teach the biology section of SS&C.

Every year the ninth grade non-Regents classes were exceptionally small so the teachers had time to provide individual attention. The students were generally willing to participate in class activities and discussions and enjoyed the opportunities provided for lots of hands on activities. The students also seemed to enjoy the more inquiry aspects of the course as reflected by them asking their teachers "what will happen" or "would this work." As can be expected from the selection criteria for placement into these ninth grade courses, the students are not highly motivated and get off task easily. Generally the teachers retained the students' attention through lots of personal interaction with the small groups and through discussion sessions with lots of short answer questions (generally related to what happened in the activities) to help keep the students focused. The activities were often centered around one big idea and the teachers used the data to help the students construct that idea.

In the 1997-8 year the teachers were asked to compare the SS&C course to what they used to teach. The teachers this year included two fairly new teachers, one teacher new to the school and one "old guard" teacher. These teachers liked the hands-on integrated approach offered by SS&C and felt that they had adequate resources to teach it. The teachers saw themselves as already teaching hands-on inquiry oriented classes before SS&C so there were few changes they believed due to SS&C. Some did think that there were higher levels of student participation and more student discussion but that these did not affect student understanding or teacher/student interactions. One felt that his perception of how kids learn had been changed to be more appreciative of individual differences. Two of the teachers felt that they had changed their assessments toward more authentic types like portfolios, and though provoking questions. Two of the teachers also thought that they had more labs and for one of these it required more

preparation time. The teachers felt that SS&C had both positive and negative points that essentially balanced. They felt that there could have been a stronger emphasis on content and on teachers working as a team to deliver the course.

Teacher Enhancement

There has been some opportunity for teacher enhancement related to SS&C. The first summer a team of four teachers including the liaison teacher attended the institute in Montana and the second summer another team of four (with one repeater) and the liaison teacher attended the institute in Houston. Other than that the course has been developed and modified by the teams of teachers teaching the course. Different sets of the originally enhanced teachers taught the 9^{th} and 10^{th} grade classes in the 1995-8 years. When those without special training were assigned to teach SS&C, it was treated like any different class they would be assigned to teach. They were expected to design the course from the existing materials and their own expertise. Those who had taught SS&C before were available for questions, but no formal training was provided. There is a good deal of evidence of the teachers taking the SS&C materials and improving on it by adding new activities, incorporating mathematics or using technology. The first year the team that attended the summer workshop substantially rearranged the SS&C activities to present science themes, e.g., energy was covered in physical science then life science, then earth science and then another theme would be started. The team from another high school worked with them on the development of the themes during the summer and throughout the first year.

Analysis

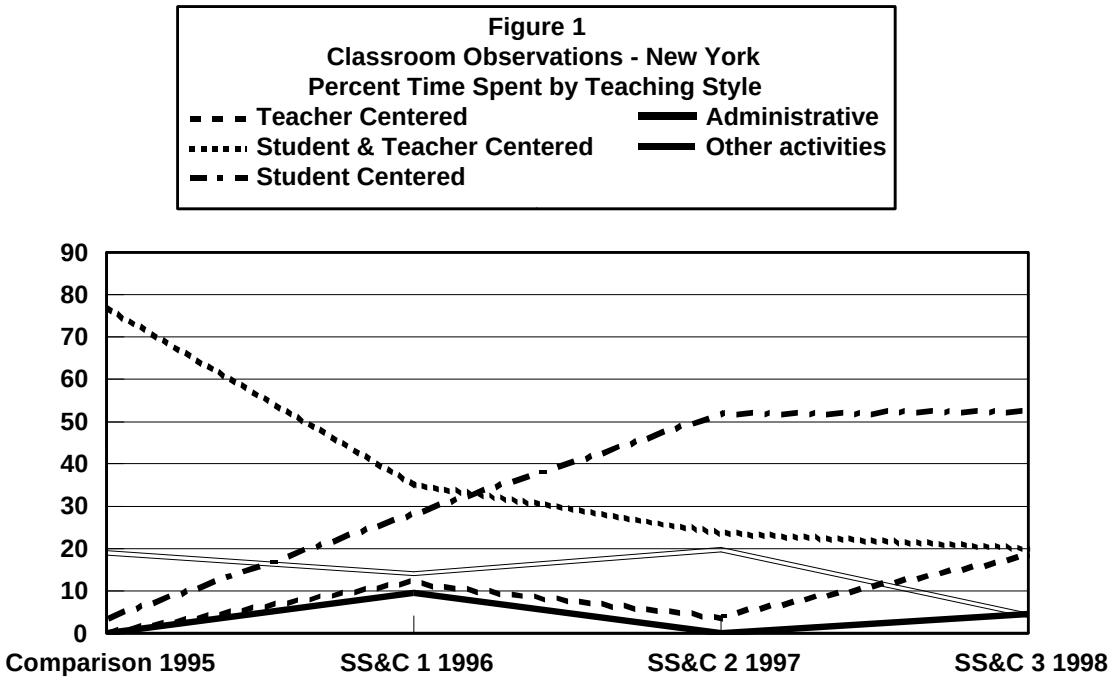
Over the four years of the SS&C project, the climate and science department has remained quite stable. As a result of this stability and consistency, we are able to attribute changes to the SS&C curriculum. As is the case in most schools, the environment was somewhat political. Everyone has classes, time slots and different approaches to solving problems that they prefer. It appears that SS&C was one of the tokens in the political power interactions. The department chair is supportive of SS&C.

Discussions about how to implement SS&C or about whether or not it should be continued were not only related to SS&C but also to which side of the power struggle was favored. In addition as is always the case with change, innovation suggests that what was formerly in place was somehow inadequate. Anyone who had ownership in an "old guard" way of doing things would feel threatened and displaced by the innovation. There was an undercurrent of "there was nothing wrong, so we don't need SS&C to fix it."

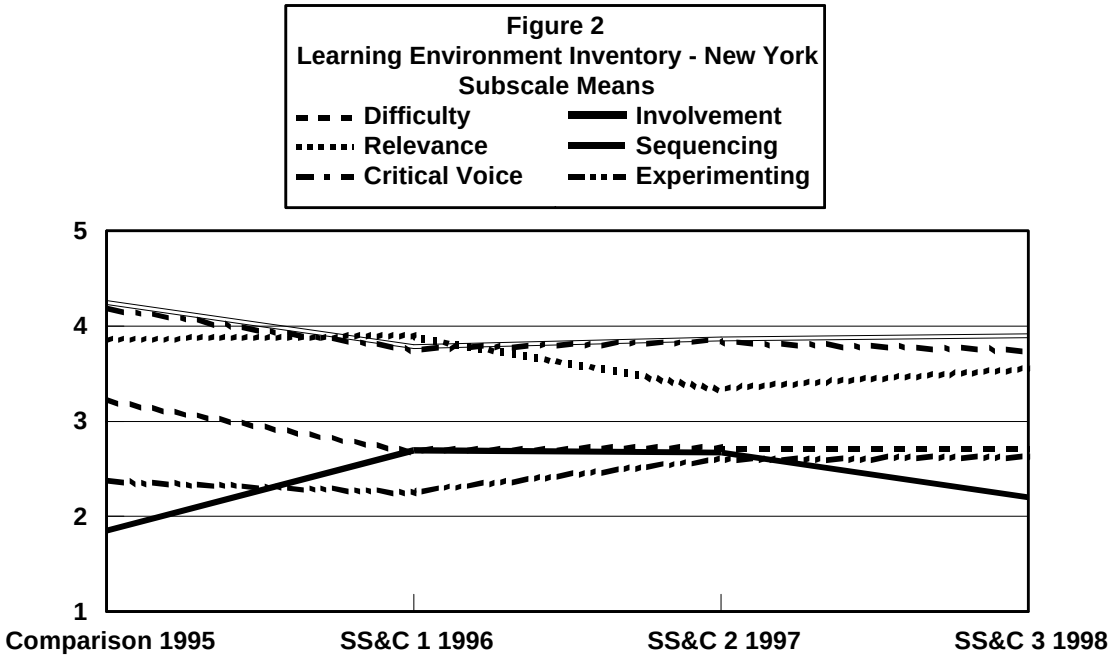
Despite the somewhat unfavorable political context, SS&C was implemented moderately successfully. Probably the most significant factor in the implementation was the attendance at the summer institute by a team of teachers. The institute itself was somewhat helpful but more important was the time alone together for the team to reflect on the needs of the students being targeted for SS&C and to redesign the SS&C activities into the thematic approach viewed as optimal. This opportunity for time away from the usual context and in a school team surrounded by others from throughout the U.S. that were enthusiastic about implementing SS&C produced a core of teachers at the high school that were committed to the project. This core lent support to the department chair in the discussions of the implementation. Another important factor was the alignment of SS&C with the new science standards. New York is very standards driven and a new curriculum matched to national standards fit the NY model nicely. This also gave the school the opportunity to be at the "cutting edge" in terms of implementing the NRC standards. Finally it was also an opportunity to "shake up" good teachers who were perhaps too set in their ways.

The difficulty of change and the political situation helps to explain why so many of the grade 9 SS&C teachers the first year were new. They have less political clout and less to loose in the implementing new procedures. In the second year (1996-7), however, the old guard played a major role and in 1997-98, one of the teachers was "old guard." In the first two years the major complaint against the project was the short term contact with the students (when it was 2 weeks each). Once this was changed, there were actually very few complaints. SS&C appears to have fit with the teachers' hands-on and problem

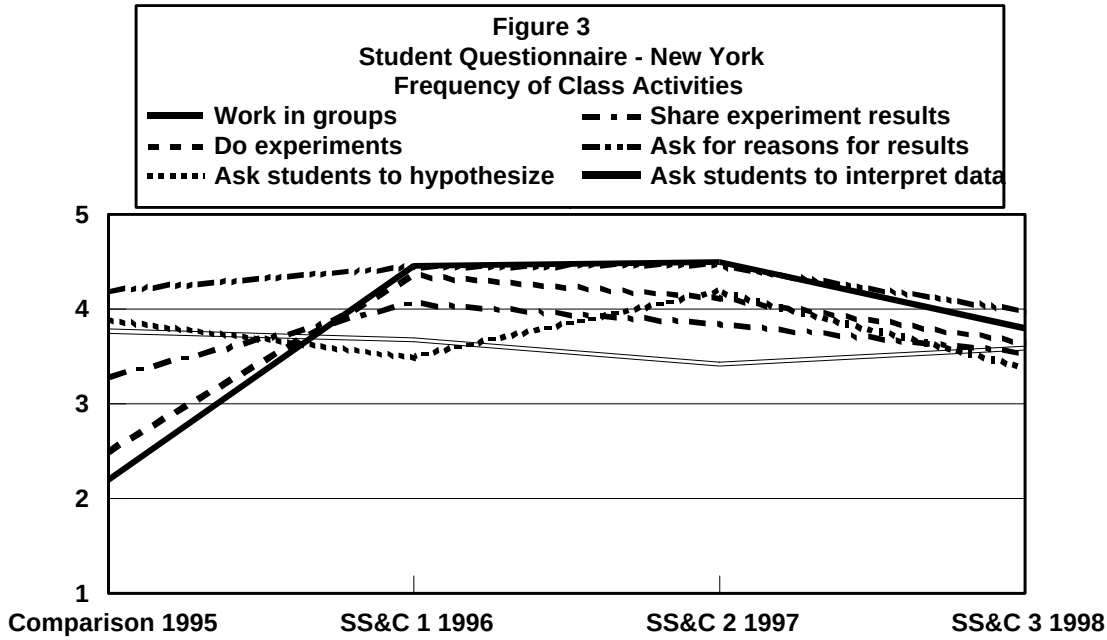
solving philosophies and offered stronger consideration of student's prior knowledge and of inquiry.



The observation data show a consistent significant increase in student centered classroom behaviors to a high of 70% of the classroom time (see Figure 1 and Table 1 in appendix). There was a corresponding consistent decrease in behaviors representative of both teacher and student centered behaviors from a high of 75% to a low of 18%. Teacher centered behavior went up from zero the first year, down slightly the second and then up again the third year but generally stayed around 10% during the SS&C years.



The Learning Environment Inventory showed some changes in the classroom psychosocial environment (See Figure 2 and Table 2 in appendix). During the first year the inventory shows decreases in critical voice, involvement and difficulty but an increase in sequencing. Critical voice, involvement and difficulty remained stable over the next two years. Sequencing remained high for one more year and then dropped off. Relevance showed a drop in year 2 with a comeback in year 3. The only differences between the comparison and the other years that were statistically significant were for the sequencing scale for 1996 and 1997.



The student questionnaire data show mixed results (See Figure 3, 4 and 5). The first year of SS&C showed increased use of student centered instructional strategies like working in groups (statistically significant from the comparison year for all three years), working on projects (significant for all three years), doing experiments (significant for all three years), sharing experimental results and asking reasons for results. There was a decrease in asking students to hypothesize and to interpret data. Over the next years doing experiments deceased along with group work, sharing experimental results, asking reasons for results and asking students to interpret data. There was an increase in 1997 and then a drop in 1998 in asking students to hypothesize.

The first year of SS&C there was a significant decrease in reading science texts and in reading other science material but an increase in reading science articles. The reading of science articles and other science materials increased the second year with the difference for articles being significantly different from the 1995 year and then the third year both dropped to below original levels. There were no significant changes for the other items on the student questionnaire such as lecturing or film watching.

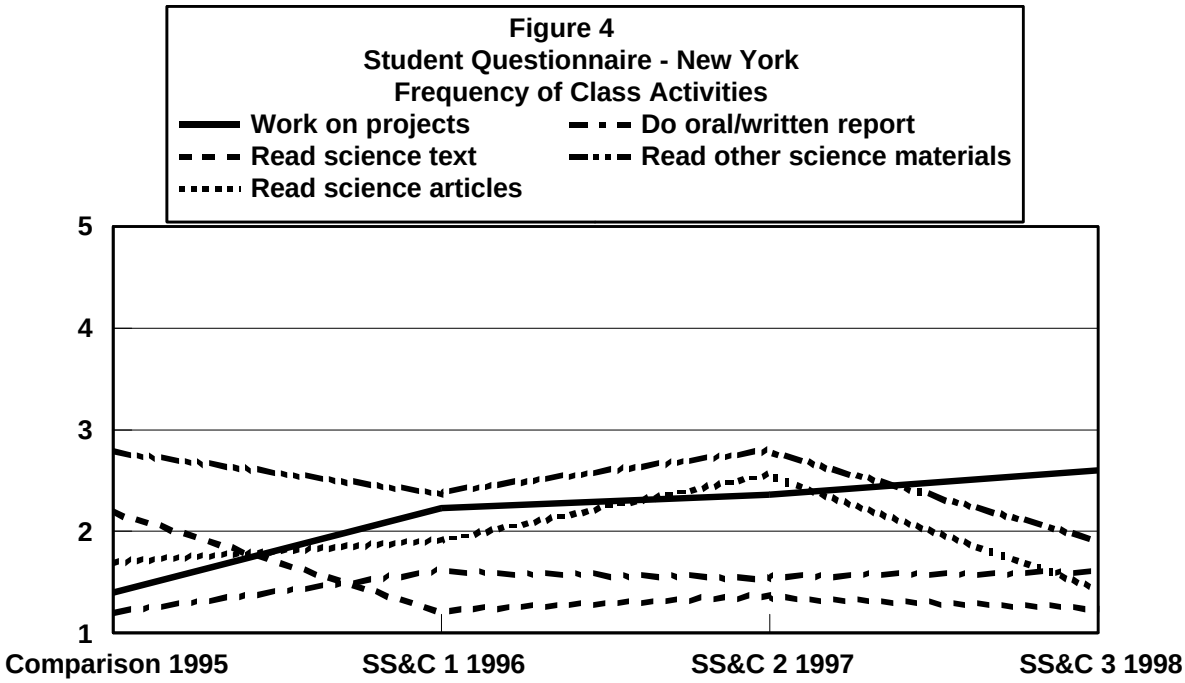


Figure 4
Student Questionnaire - New York
Frequency of Class Activities
Work on projects
Do oral/written report
Read science text
Read other science materials
Read science articles
5
4
3
2
1
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998

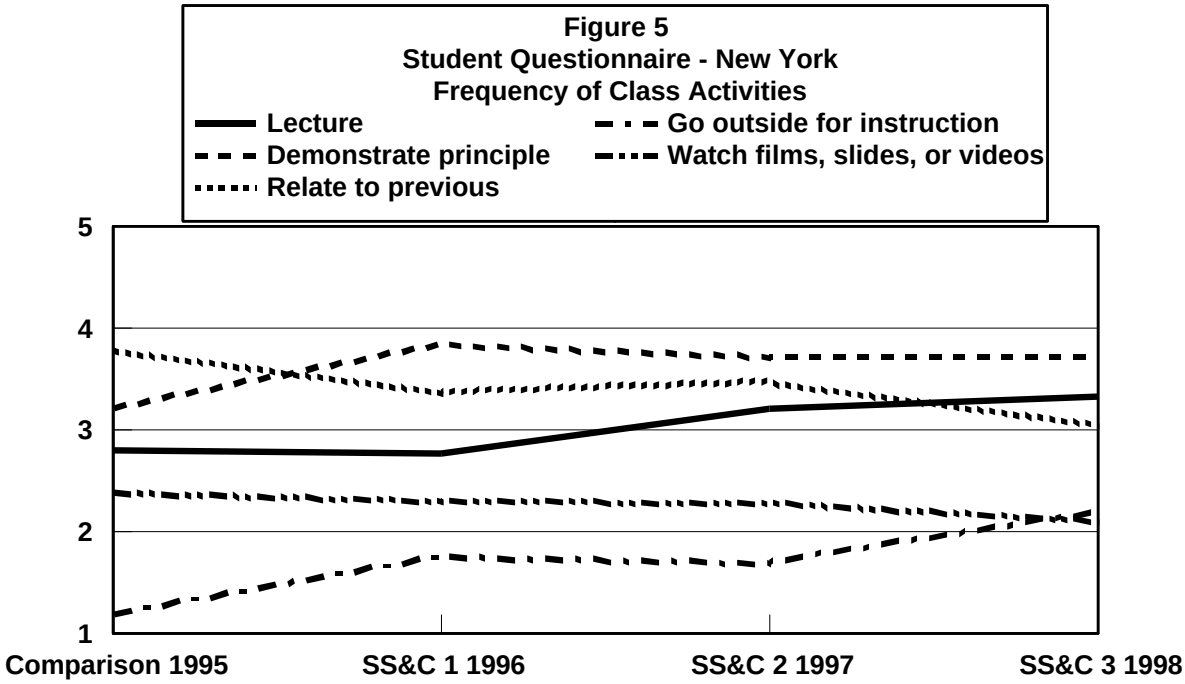
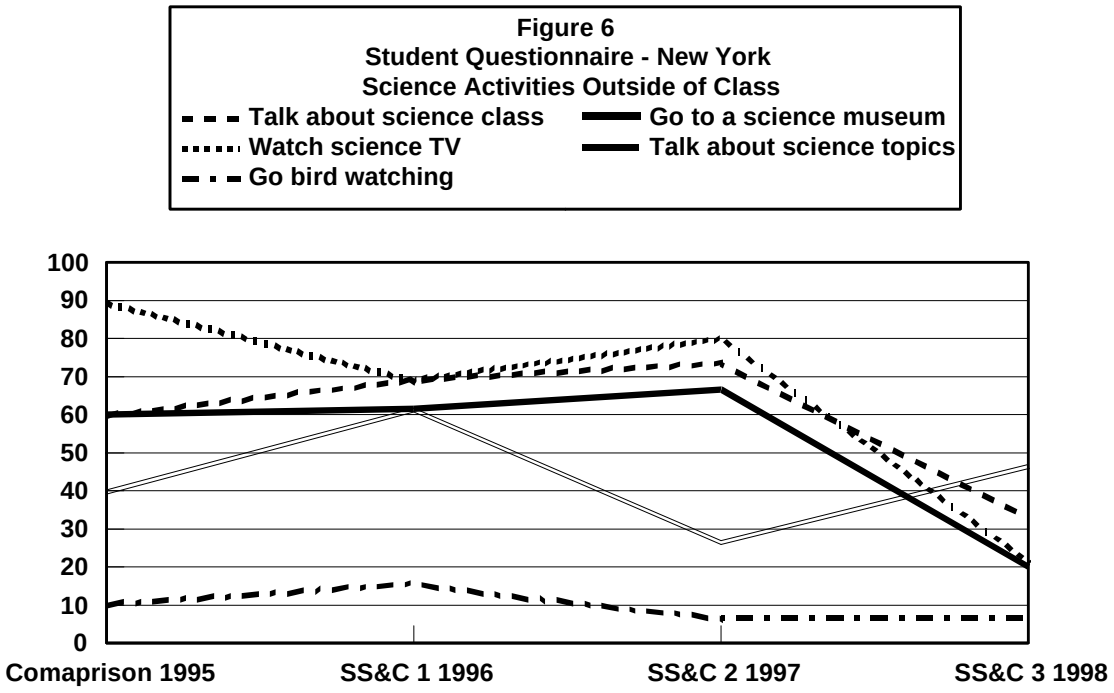


Figure 5
Student Questionnaire - New York
Frequency of Class Activities
Lecture
Go outside for instruction
Demonstrate principle
Watch films, slides, or videos
Relate to previous
5
4
3
2
1
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998



The engagement in science activities outside of school was very mixed with some behaviors showing increases and others showing decreases (See Figure 6 and Table 6 in appendix). Over the four year period, however, there appeared to be a general decrease in these types of behaviors. Both talking about a science topic and watching science programs on TV showed a significant drop from 1995 to 1998. One of the most striking findings was for the second year of SS&C where the reading of a science magazine topped out at 100% of the students. This was no doubt due to the requirement of one of the SS&C teachers for the students to do this.

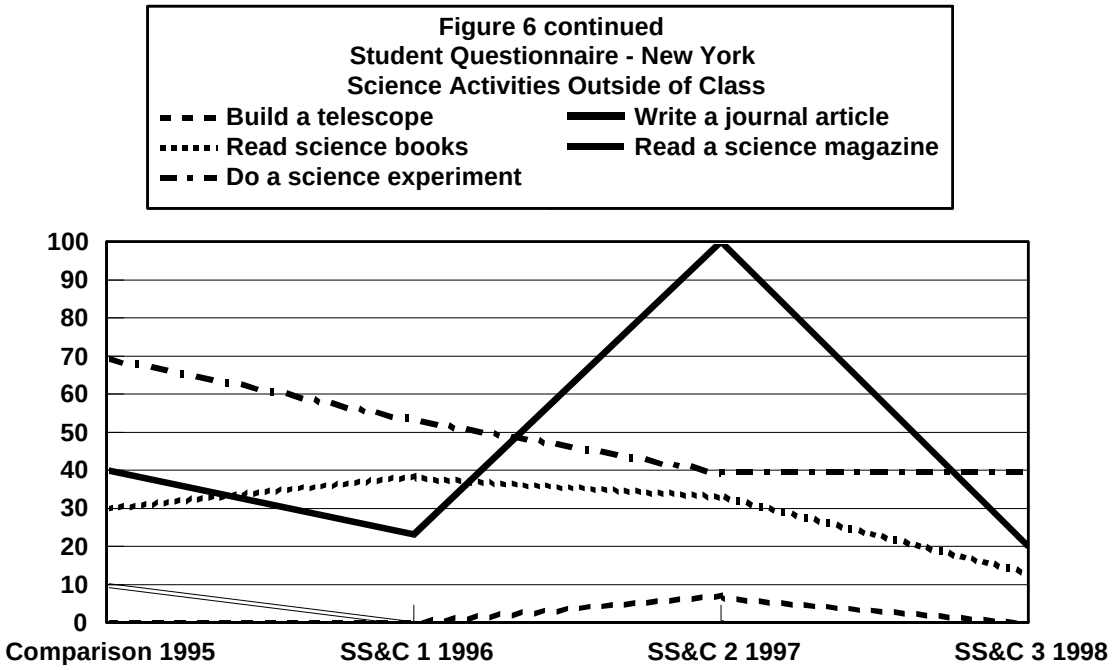
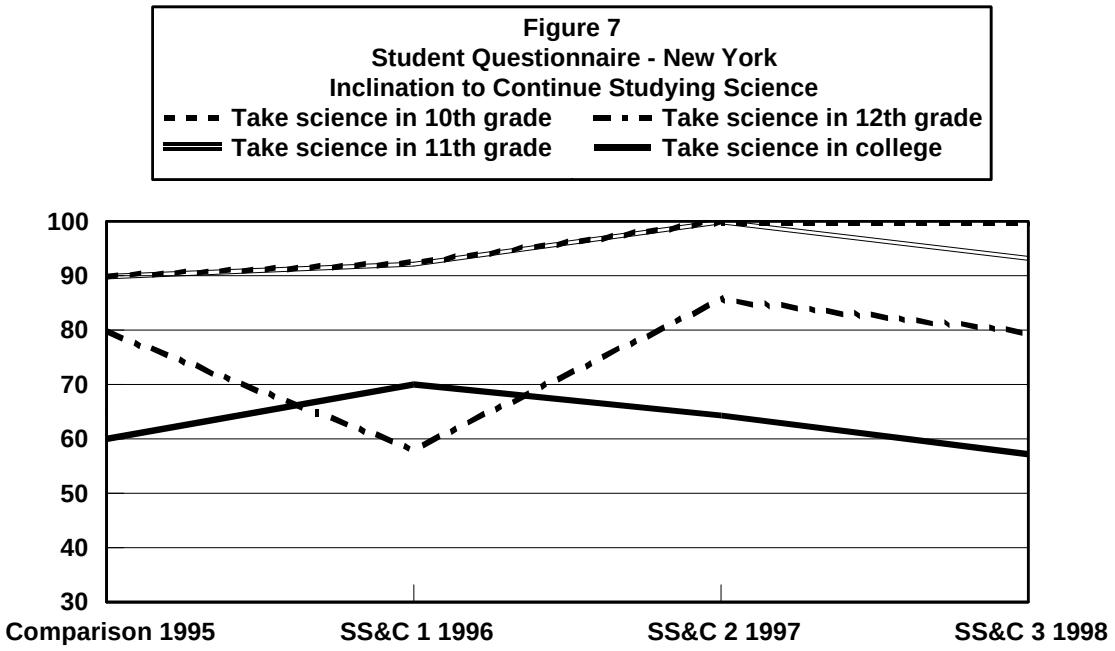


Figure 6 continued
Student Questionnaire - New York
Science Activities Outside of Class
Build a telescope
Write a journal article
Read science books
Read a science magazine
Do a science experiment
100
90
80
70
60
50
40
30
20
10
0
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998



There appears to be little change in the student's science taking preferences except for 12th grade science (See Figure 7 and Table 7). This is most likely due to the changing State graduation requirements. The students' perceptions of the relevancy and usefulness of science were fairly consistent until drops in the third year of SS&C. The motivational items (including interest and fun) show that the students were most motivated the first year of SS&C and they went down from there to a level below the comparison year. The drop in their opinion of their science classes being interesting and motivating from 1995 to 1998 was statistically significant. (See Figures 8 and 9)

Figure 8
Student Questionnaire - New York
Science Motivation

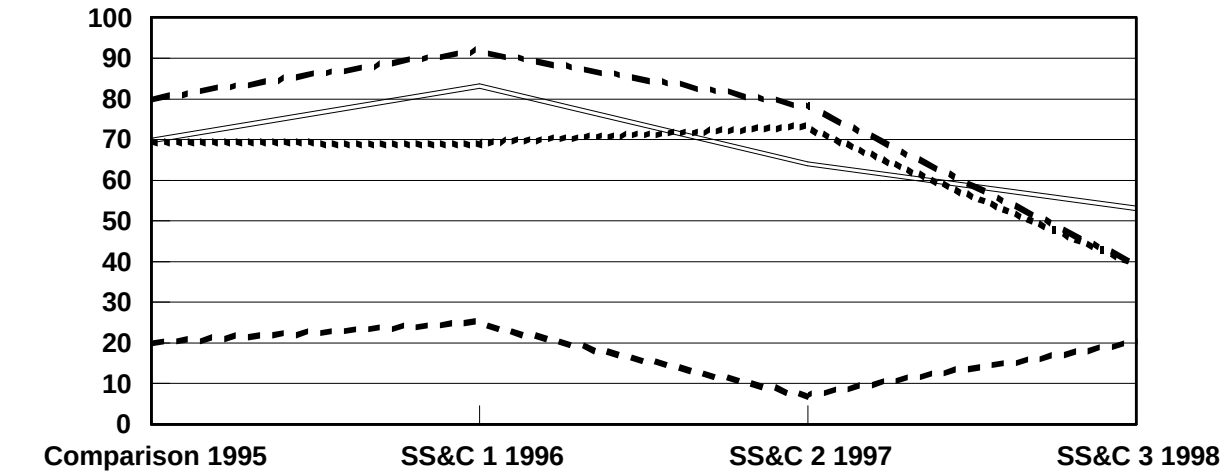
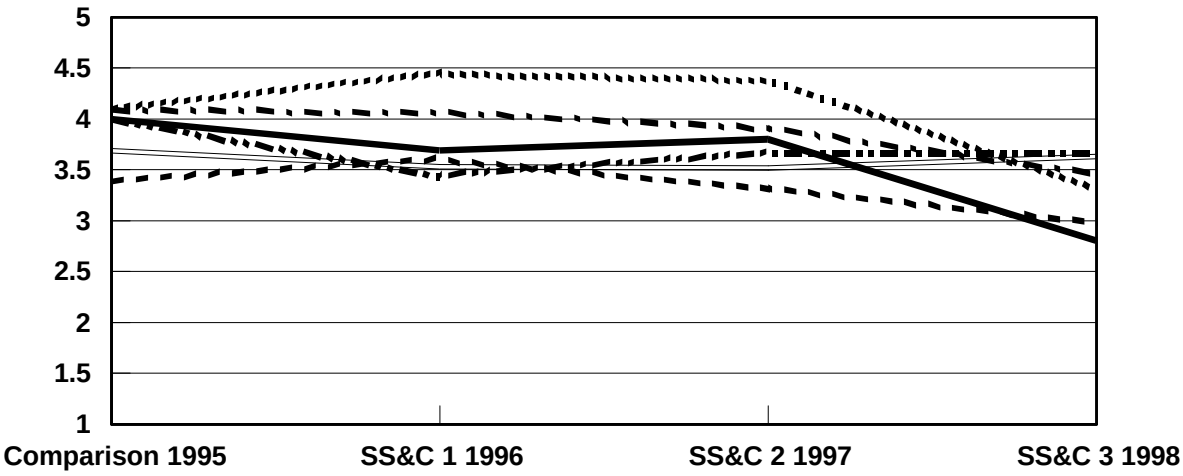
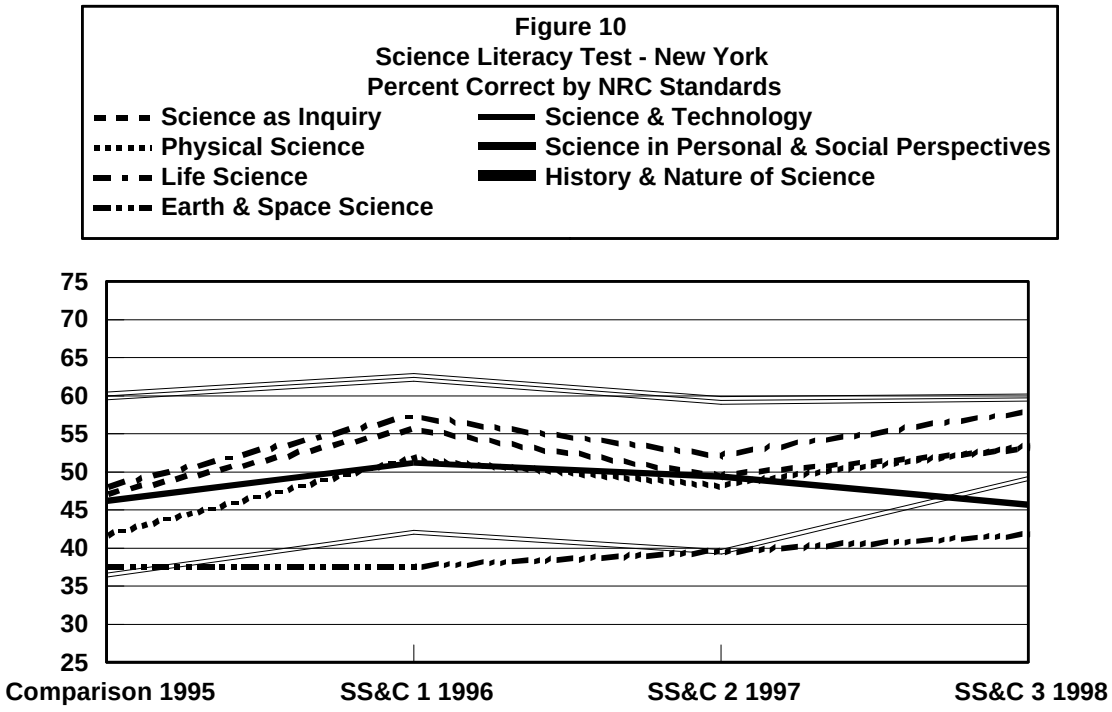
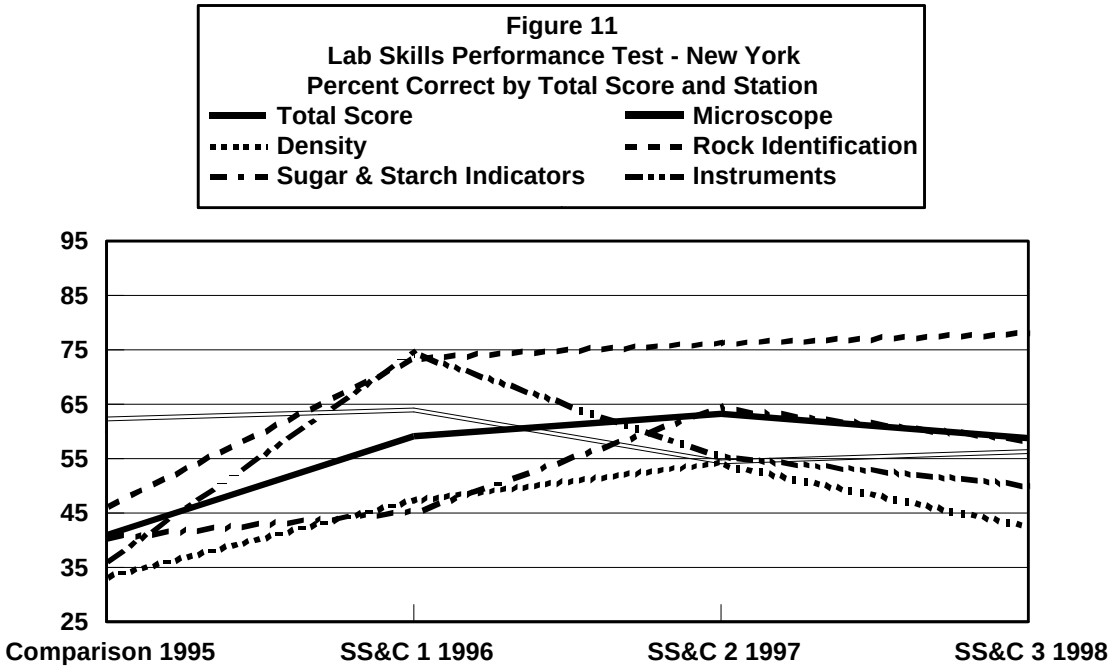


Figure 9
Student Questionnaire - New York
Attitudes Toward Science

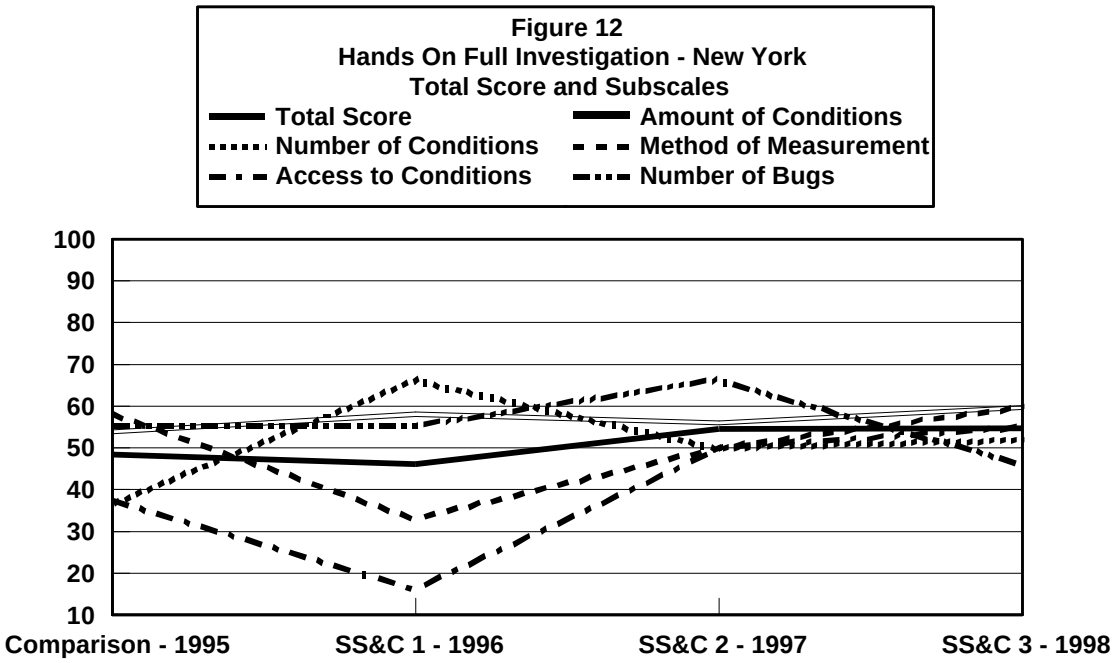




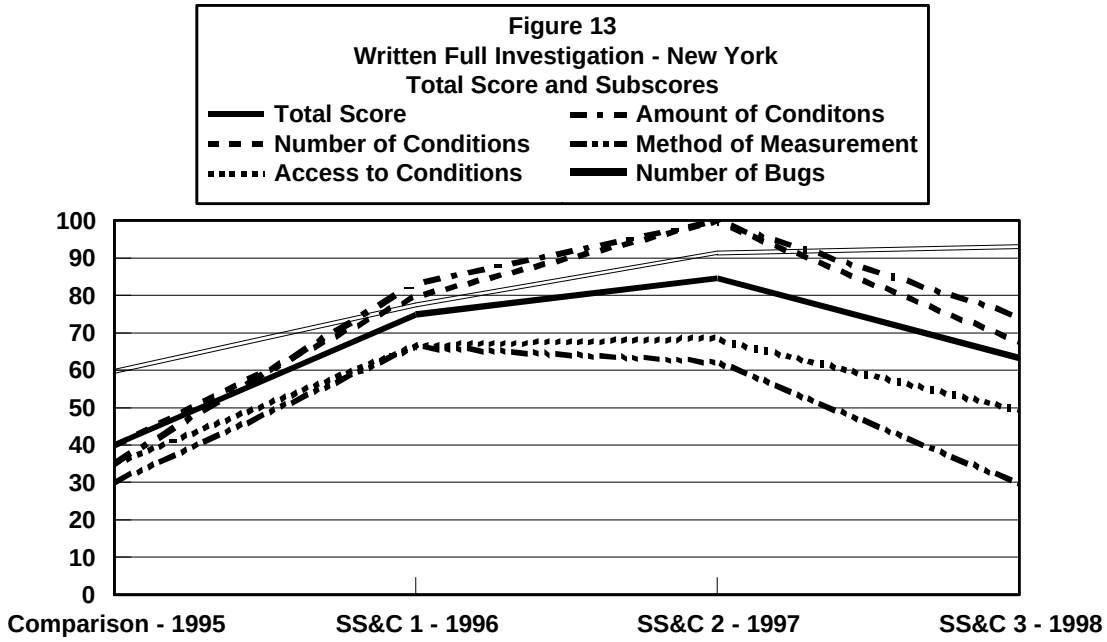
The science literacy test showed increases the first year followed by decreases the second year and returns to the higher levels by the third year (See Figure 10). The differences the first year were statistically significant for life and physical sciences and at the 0.08 level for inquiry and total score. There were no statistically significant differences between the comparison year and the second year of SS&C but there were significant differences between 1995 and 1998 on physical science, life science and history and nature of science and at the 0.08 level differences on the science in personal and social perspectives scale.



This pattern of achievement was only partially reflected in the laboratory skills tests. (See Figure 11). The students did go up in everything the first year with statistically significant increases in total score, rock identification and instruments but then different types of skills showed different patterns. Overall there was an increase from the first to the second years of SS&C and then a decrease the third year. Despite this decrease, the total score remained significantly higher than in the comparison year. There were decreases the second year in instruments (to the same level as the comparison year) and microscopes but increases in rock identification (remaining significantly higher than the comparison year), density and indicators (becoming significantly higher than the comparison year). The third year all but microscopes and rock identification decreased. Only indicators and rock identification remained significantly higher than in the comparison year.



The hands on full investigation showed a slight decrease the first year of SS&C and then a slight increase the second year which was maintained into the third year. The written full investigation showed significant increases the first and second years but returned to original levels by the third year. (See Figures 12 and 13).



Concluding Remarks

The first year of the SS&C implementation in New York seems to have produced the most striking changes both in environment and achievement. The learning environment changes appear to be directly related to SS&C which required the use of hands on activities and specific sequencing. The teachers this year were also the ones who volunteered to attend the training and who were most enthusiastic about the SS&C curriculum they developed for use in their school.

The environment the second year was accompanied by decreases in student achievement on the literacy test but not on the hands-on skills. This may be related to the fact that the teachers this year were not as committed to the project as those the first year. These teachers tended to be more experienced and more likely to use their own teaching styles and materials than the SS&C materials and philosophy. There was also a good deal of dissention about the project mostly centering around the changes of instructors every two weeks. It is possible that the teacher dissatisfaction contributed to the slight decreases in student outcomes.

In the third year the classroom environment had somewhat mixed effects on achievement. The lab skills show decreases but were still significantly higher than the comparison year. Most areas of the literacy test showed increases to almost the level of the first year of SS&C with science in personal and social perspectives and earth and space sciences moving higher (but not statistically so) than the first year of SS&C. These findings fit with the fact that there was a very strong earth science teacher as the biology part of the team this year. Also the teachers this may not have been as committed to SS&C since none had been involved in the national enhancement efforts and the teachers were aware that the State was thinking about changing its science requirements for graduation.

VI. The Montana Junior High School Experience

School Setting

Montana Junior High School is an 8th and 9th grade junior high school located in a large valley in the Rocky Mountains of northwestern Montana. The school is located in a small city with a population of approximately 15,000 people, however, the school serves communities throughout the larger valley, including rural areas near Montana. Ranching, farming, and recreation are the largest businesses that support the community. Montana is near national forests and a ski resort, and as a result the city of Montana has many recreation and tourist related businesses. The student population at Montana Junior High School is predominately middle-class and Caucasian. None of the observed classes appeared to have any minority students. The majority of students are college bound and appear motivated about learning and doing well in school. The school itself is a traditional 2-story brick building. It is clean and well maintained and all indications are that the school is well funded and equipped. The science classrooms are clean, well equipped with science apparatus, and nicely decorated with science related posters. The atmosphere of the building is very upbeat. The staff and students are quite friendly and welcoming. The school serves approximately 550 ninth graders.

Science Program

The science department is extremely hard working and motivated about helping kids learn. Montana converted to SS&C because of the leadership of the science department. chair at the senior high school. The chair originally wrote a grant to implement an integrated science curriculum in the state of Montana. Their proposal was not funded by NSF, however, Bill Aldridge heard about their interest in integrated science and asked them to join his SS&C project. Montana got involved with SS&C because many of the students only take the required two years of science, and teaching every science every year was a way to expose all students to more than just earth science and biology. The staff also believes that all of the sciences are inter-related and should be taught together to properly represent reality. The staff found the inquiry-oriented approach appealing

because so many of their students were bored with the traditional, lecture-oriented approach.

At Montana Jr. High there are eight class periods during the day, each lasting approximately 50 minutes. All of the science classrooms are located in one area of the building, clustered around central storage facilities. Montana Jr. High does have tracking arrangements in science. Before SS&C began (the 1994-95 school year), Montana Junior High had a mixture of tracked 9th grade science classes. They offered Earth Science (honors, regular and basic), and Biology. Students self-selected which class to take, however, advanced students were advised to take either biology or honors earth science, the majority of students took the regular earth science, and the least academic students took the basic earth science. The comparison data analyzed below only includes data from the regular and basic classes, not honors class since they were not converted to SS&C.

In the first year of SS&C (the 1995-96 school year) they offered 7 classes of SS&C, 2 were "Basic SS&C" and 5 were "Standard SS&C". Both tracks did the same activities, however, at the basic level classes takes one extra class period to discuss each activity. This means they progress through the curriculum at about half the pace of the standard track. The science department still continued to offer biology and honors earth science for their advanced students who do not take SS&C. As a result of these course offerings, SS&C became a class for average or below average students, while the best students opted not to take SS&C.

There are two 9th grade science teachers who have been involved in the SS&C program from the very beginning. Only one of these two teachers attended summer SS&C workshops. This teacher has served as the lead SS&C teacher from the very beginning and continues to serve in this role today (the fourth year of the project). Montana Jr. High has developed a very organized system for delivering the curriculum. One of the teachers has taken a leadership role and has organized all of the materials for each

activity. This teacher has taught five sections of SS&C and gets all of the materials ready for the day. They have scheduled classes so that most SS&C classes meet at a different time, and as a result they can share materials. The materials are placed on a cart. One teacher uses them and then passes them on to the next teacher. This also allows the first teacher to pass on tips to the other teachers and to discuss what went well and what needs modification. As a result of this organizational system the teachers have mentioned in interviews that they do not spend any more time preparing for SS&C than they do for other classes. In reality, it seems that the initial work of 1 or 2 teachers organizing all the materials, has reduced the amount of time other teachers spend preparing for class.

Over the last three years, the SS&C program at Montana Junior High has been growing in terms of the number of students that choose to take the course. In the first and second year there were 7 classes and 6 classes respectively. The third and fourth year saw an increase to 9 classes and 10 classes respectively. Interviews with the lead teacher indicated the increase in enrollment was due to more students choosing to take SS&C rather than earth science or biology. According to this teacher, the students in honor classes and biology heard that SS&C was more interesting and more fun and chose to enroll in the class. The science teachers at Montana Jr. High said they would ultimately like all students to take SS&C, however, so far they are still allowing students to choose classes rather than require all students to take SS&C.

School Climate

The principal at Montana Jr. High School is very supportive of SS&C and believes that the teachers are doing an excellent job of implementing the curriculum. Based on the increased student enrollment in SS&C the principal is quite pleased with how the course has been received and believes the program is succeeding and serving students very well. The principal thought the teachers are doing an outstanding job of implementing SS&C.

The school itself has a very positive climate. The students are quite motivated about learning and many are college bound. The school in many ways has a typical junior high

feel. It is very active and social. There are occasional social problems. During one visit last year a large group of students were suspended for fighting. During another visit a student was expelled for bringing a loaded gun to school and as a result the school was practicing a lock-down drill in case of gun violence. The teachers told me they feel safe, but since guns and hunting are such an integral part of Montana culture they do occasionally have problems with students who bring hunting weapons to school. The only other climate issue that seems to permeate he school is the emphasis on snowboarding and the out of-doors. Many student wear the latest snowboarding / skiing fashions and have an attitude that it is cool to be a slob.

Science Department Climate

The science department has a very positive climate. It's a small science department with a total of six teachers, and they all share a common office. During the site visits all of the teachers were friendly and welcoming and appear to enjoy teaching at Montana. The two teachers that primarily teach SS&C are both veterans that have been in the field for over 20 years. They appear to enjoy each others company and have worked hard together at planning the lessons and gathering all the equipment necessary to implement the SS&C activities.

A third teacher began teaching SS&C just last school year (1997-98). This teacher taught two classes of SS&C with the help of the lead teacher. Since the lead teacher has organized materials so well, the transition for a new teacher appeared to go quite smoothly. None of the teachers at Montana have complained about the amount of time required to implement SS&C. This appears to be due to the organized nature of the lead teacher.

Curriculum, Instruction & Assessment

At the 9th grade level, Montana Junior High School has continued to use most of the priority SS&C activities; they do not do the secondary activities. They have modified the activities to a slight degree, but most of the modification has been to help the activities fit

their equipment. They also refined some labs that did not work well. In addition they use the original 9th sequence provided by SS&C. The only aspect of the curriculum that they do not use is the readings. They found the historical readings provided by SS&C to be too difficult for their students. The readings in old English were especially difficult for their basic level students to comprehend, much less read.

As far as instruction goes, all of the teachers were observed to be using an inquiry-oriented sequence. They described themselves as more facilitators of learning rather than purveyors of knowledge. They do many more hands-on activities than they did before SS&C began and they believe that the students are much more actively engaged in science than they used to be. They even believe that the students discuss more in class because of SS&C. The have found that SS&C has helped encourage students to discuss more in small groups and in whole class discussions. The teachers also believe that the students are learning much more from SS&C than they did in traditional science. They seem to retain better and have learned more lab skills. All of the teachers indicated that they have significantly changed the way they teach because of SS&C. They have always used labs and believed in hands-on science, but with SS&C they never gave students so much control and input into doing science. In the past, labs were traditional cookbook style labs with all the procedures dictated to students. The more inquiry-oriented methods have opened their eyes to how much more students can do. It made one of the teachers see that students really can learn more than she thought. The inquiry teaching has also changed teachers' interactions with students. They are able to spend more time moving from group to group, answering questions and discussing. Previously the teachers spent more time talking to the whole class rather than talking to small groups and individual students.

All the teachers indicated that their labs are more open-ended than they used to be. In interviews the teachers they said that 80-90% of the labs provide "some" suggestions for students on how to do the lab, but also allow students the opportunity to use some of their own procedures. The teachers indicated that they would like to move towards even more

open-ended lab activities if possible. Right now only 10% of their labs allow students to design their own procedures, and none of them allow students to come up with their own problems to study.

The teachers thought that the best way the course could have more impact is to add some readings to the curriculum. As mentioned they have dropped the readings that were developed by NSTA, with the exception of a few that were easier to read. They would like to find more readings to supplement the lab activities.

The teachers at Montana have also changed the way they assess students. They have stopped using multiple-choice tests and have gone to written problem solving tests and hands-on tests. They also try to cast all tests in real-world contexts. They claim the tests now more closely match the instruction and the skills they expect students to learn.

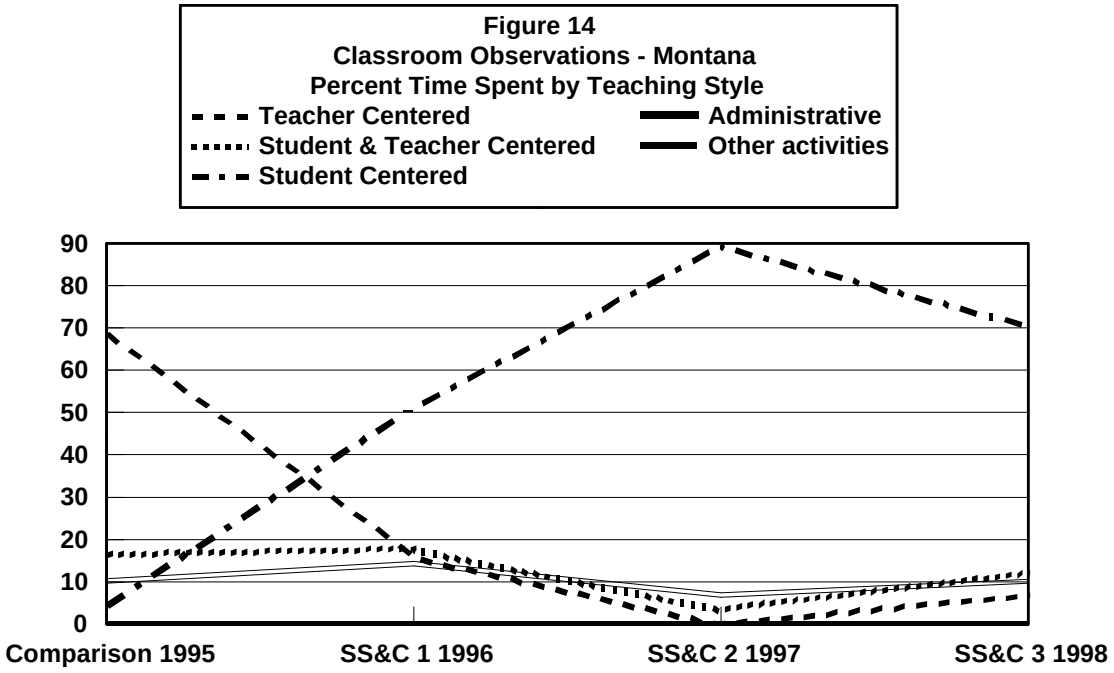
Teacher Enhancement

Only one of the 9th grade teachers at Montana attended the summer workshops offered by the original SS&C grant. The teacher enjoyed the workshops and meeting with other teachers across the country who were also using SS&C materials, however, she did not think that the workshops had a great impact on her teaching. The teachers at Montana appear to get more out of working with each other and modifying the materials based upon their department meetings. Working as a team they have struggled with the first year of SS&C and have solved many of the implementation problems themselves. The process of working together to implement SS&C seems to have had the greatest impact of all enhancement activities. The summer workshops appear to have much less impact on the teachers than actually implementing the SS&C activities in their own classrooms.

Analysis

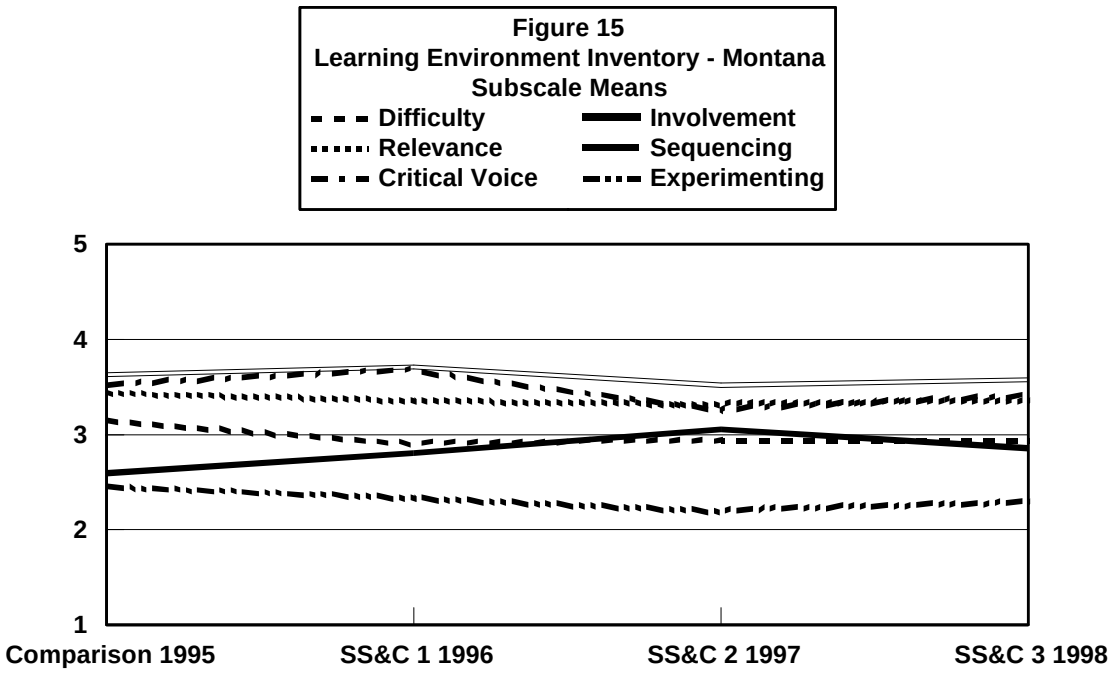
Over the four years of the SS&C project, the climate and science department has remained quite stable. The same two teachers taught during the comparison year and

have taught SS&C for the last three years. As a result of this stability and consistency, we are able to attribute changes to the SS&C curriculum.

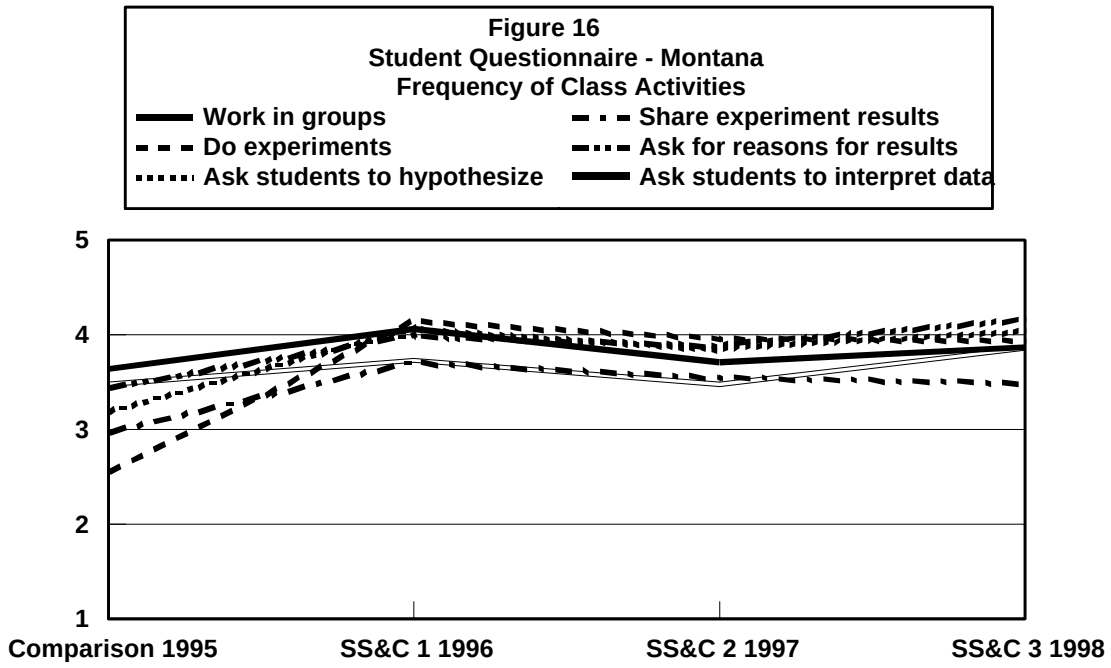


As indicated by the class observations, the learning environment changed dramatically from the comparison year to the first SS&C year and has continued to remain very student-centered (See Figure 14 and Table 14 in appendix). During the comparison year we observed that teacher-centered activities dominated instruction (approximately 70% of class time). Teacher centered activities included lecture, teacher-controlled seatwork, reading the textbook, etc. In contrast, student-centered work was only observed in approximately 5-10% of the class time. Student-centered work includes experiments, student discussions, groups work, etc. During the first year of SS&C these two types of activities flip dramatically. Teacher-centered activities dropped to 15% of the time while student-centered activities increased to over 50% of the class time. During the second year of SS&C the change was even more pronounced. Student-centered work increased to almost 90% of the time and teacher-centered work dropped to less than 5%. By the third year, the trend is a movement back, as more traditional activities are increasing and

student-centered activities are dropping slightly. Overall, it is clear that SS&C dramatically changed the nature of class activities and so far the switch to more student-centered activities appears to be in tact.



The student questionnaire results also support a significant change in the learning environment at Montana Junior High (See Figure 15 and Table 15). There were significant decreases in difficulty and significant increases in critical voice, experimenting and sequencing. During each of the SS&C years, the students reported that they had more voice in the class activities, they engaged in more open-ended experiments, and the class used a more inquiry-oriented sequence where hands-on activities preceded lectures and discussions. These results are consistent with evaluators' observations of classes as more inquiry-oriented and as having students engage in more hands-on science activities.



On individual questions about class activities the students indicated that from the comparison year to the first year of SS&C there was an increase in the frequency of doing experiments, sharing the results of experiments, hypothesizing, giving reasons for the results of experiments, interpreting data, and working in groups. (See Figure 16 and Table 16). Likewise, the students at Montana reported a decrease in reading the science textbook, reading science articles, watching videos, and listening to the teacher lecture. (See Figures 17 & 18 and Tables 17 & 18). All of these changes support our observations of the very dramatic change in the environment from a fairly traditional teacher-centered approach to a more student-centered, inquiry-oriented approach that is recommended in the National Science Education Standards. The changes reported by the students also appeared to hold steady throughout the second and third year of the SS&C implementation. The frequency of doing experiments, sharing results, hypothesizing, and interpreting data all remained high, while the frequency of traditional techniques remained low.

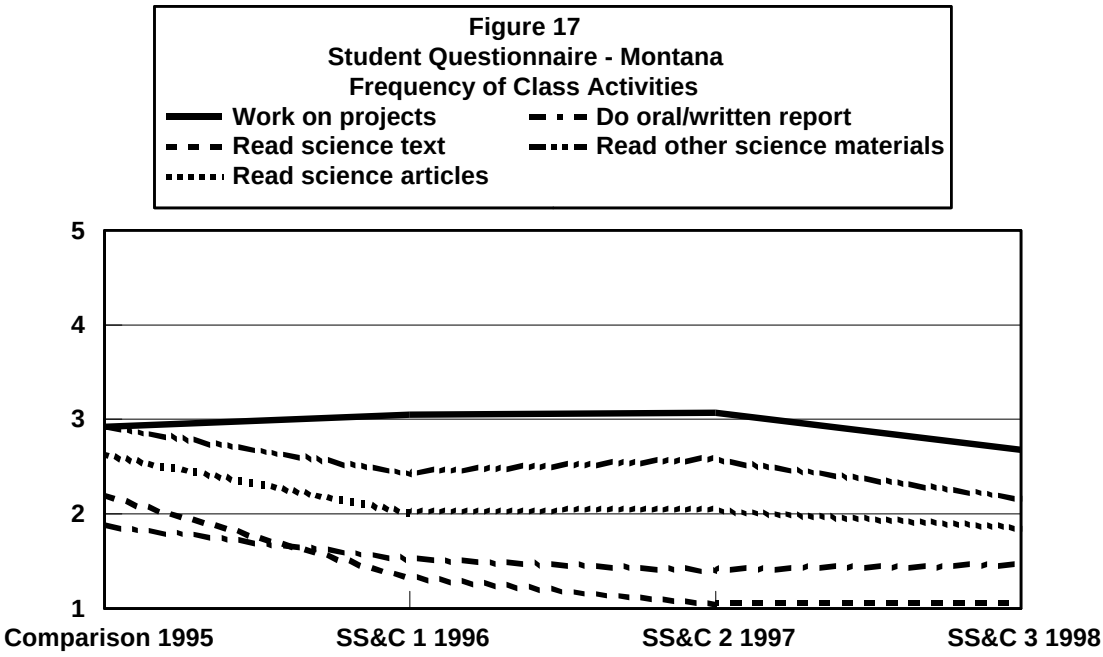


Figure 17
Student Questionnaire - Montana
Frequency of Class Activities
Work on projects
Do oral/written report
Read science text
Read other science materials
Read science articles
5
4
3
2
1
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998

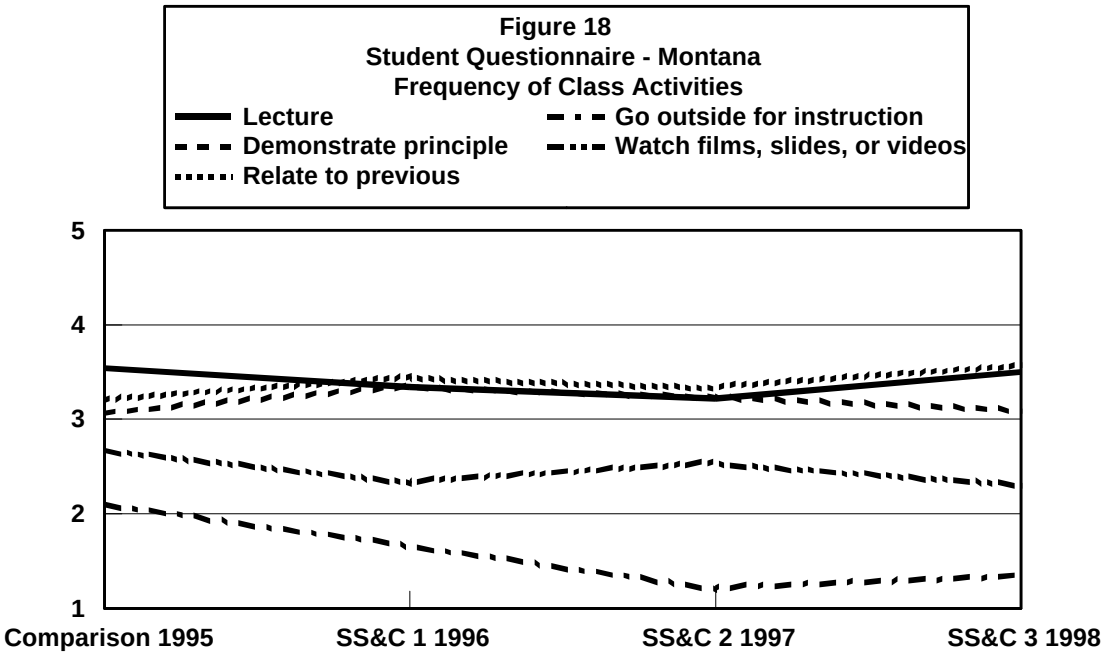
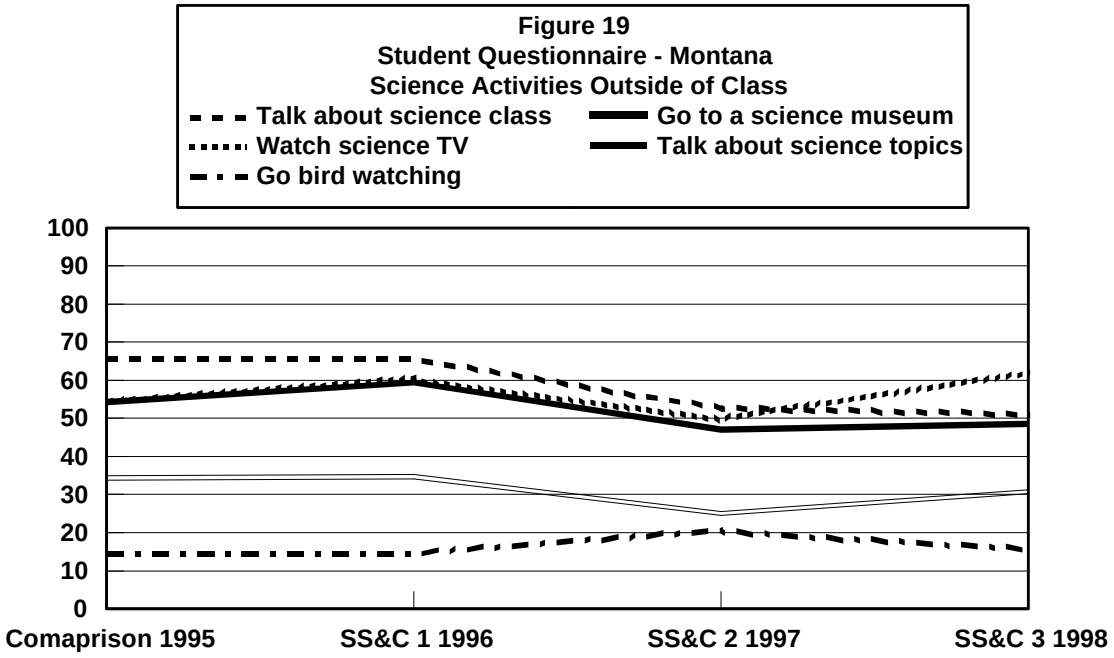
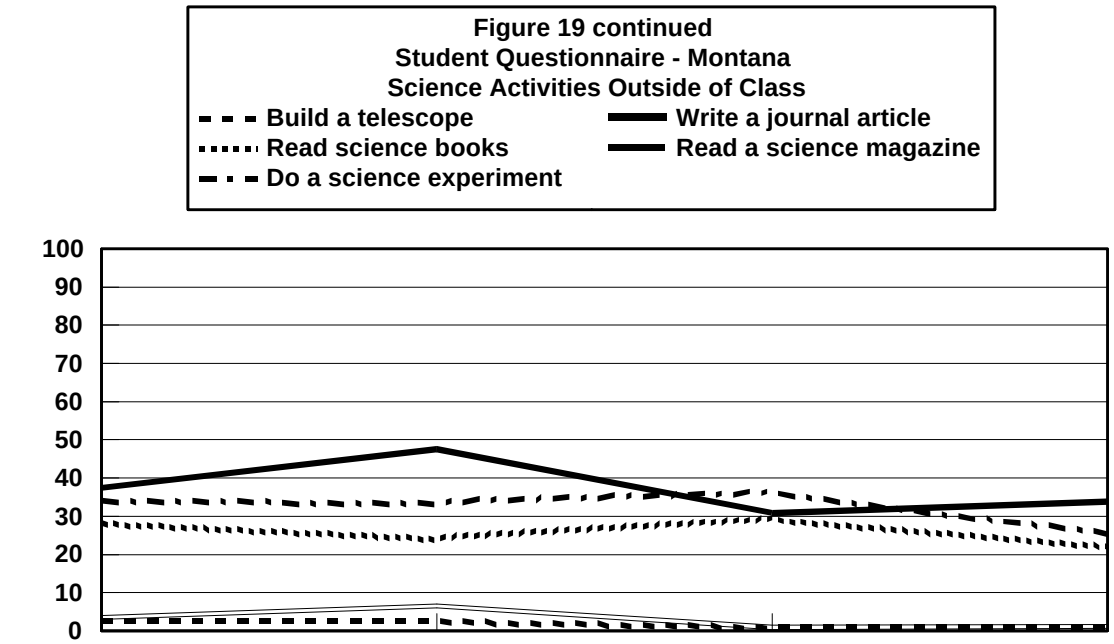
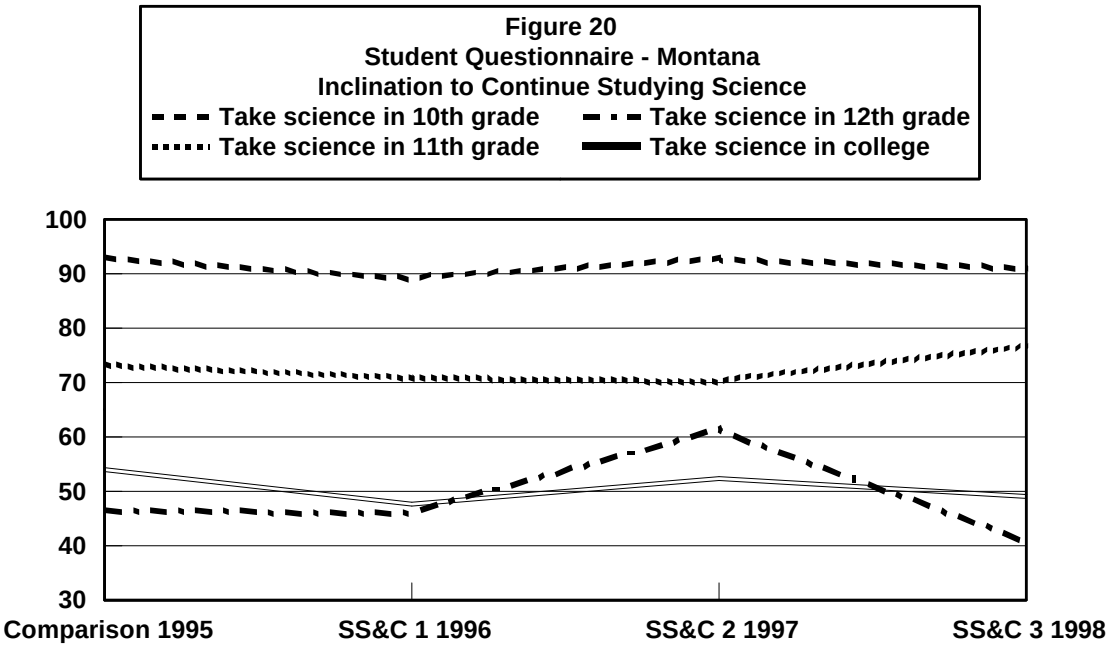


Figure 18
Student Questionnaire - Montana
Frequency of Class Activities
Lecture
Go outside for instruction
Demonstrate principle
Watch films, slides, or videos
Relate to previous
5
4
3
2
1
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998

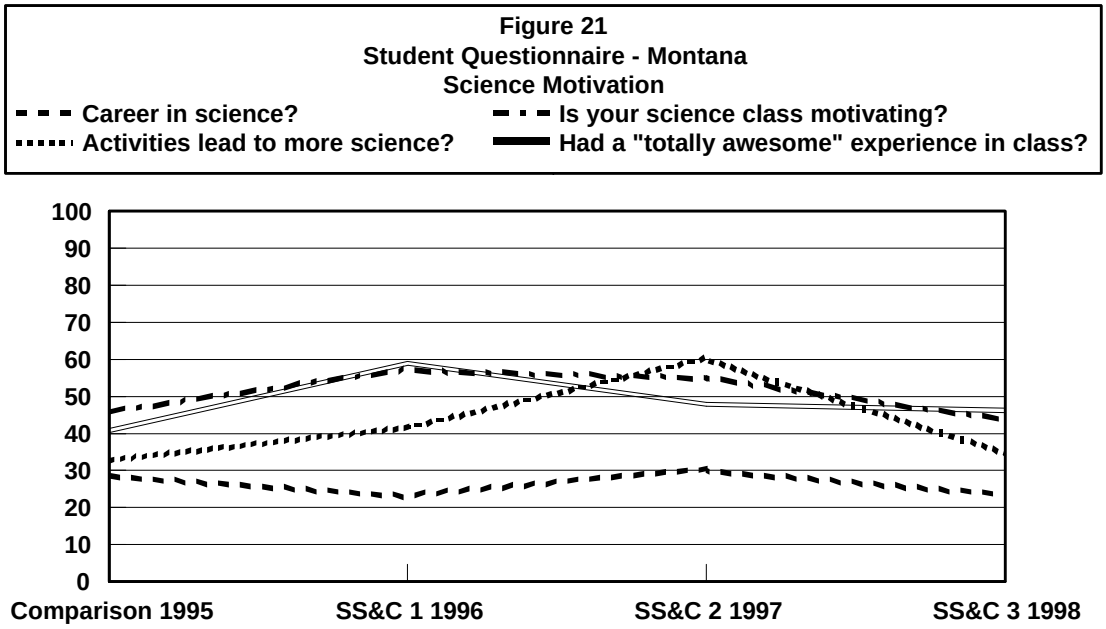
The students also reported on the frequency of science activities they do outside of class. No significant changes were found in the first year of SS&C, however, in the second and third year a decrease was noted in talking about science. (See Figure 19 and Table 19).



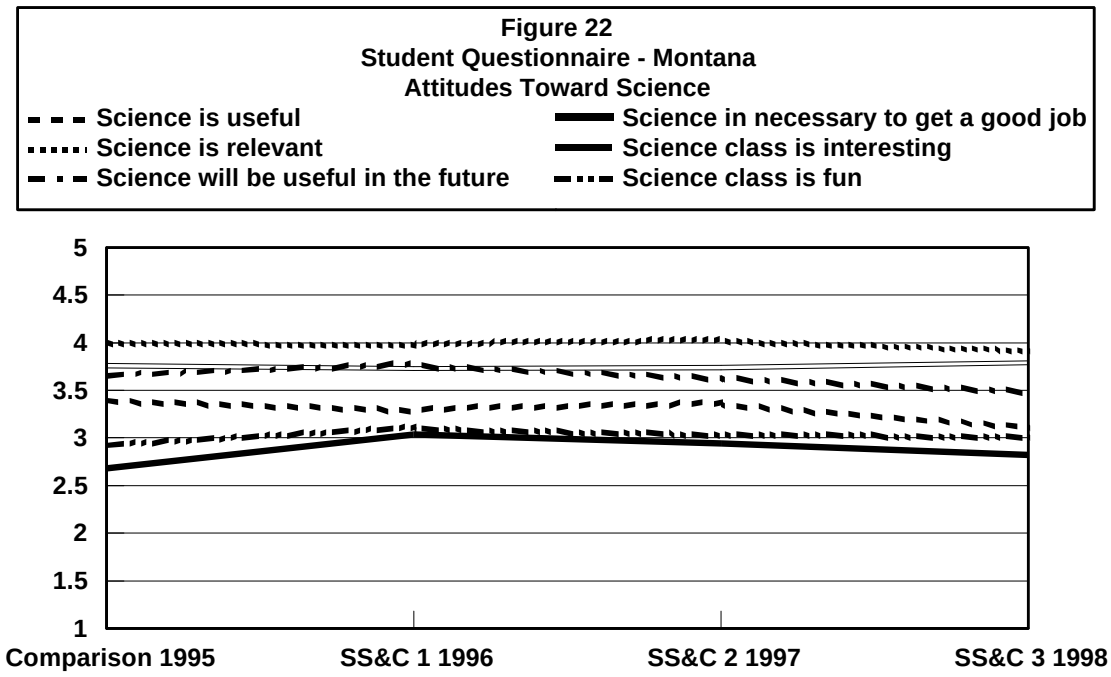




Despite the dramatic changes in the learning environment at Montana Junior High School, the inclination to study science in the future appeared to remain constant. No changes were found in students indicating that they intend to study more science in 10th, 11th, 12th grade or in college. (See Figure 20 and Table 20).

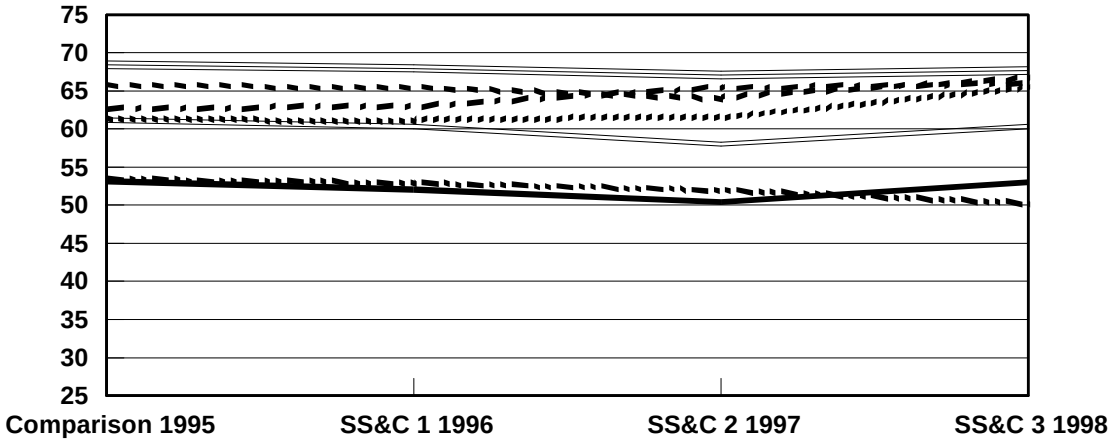


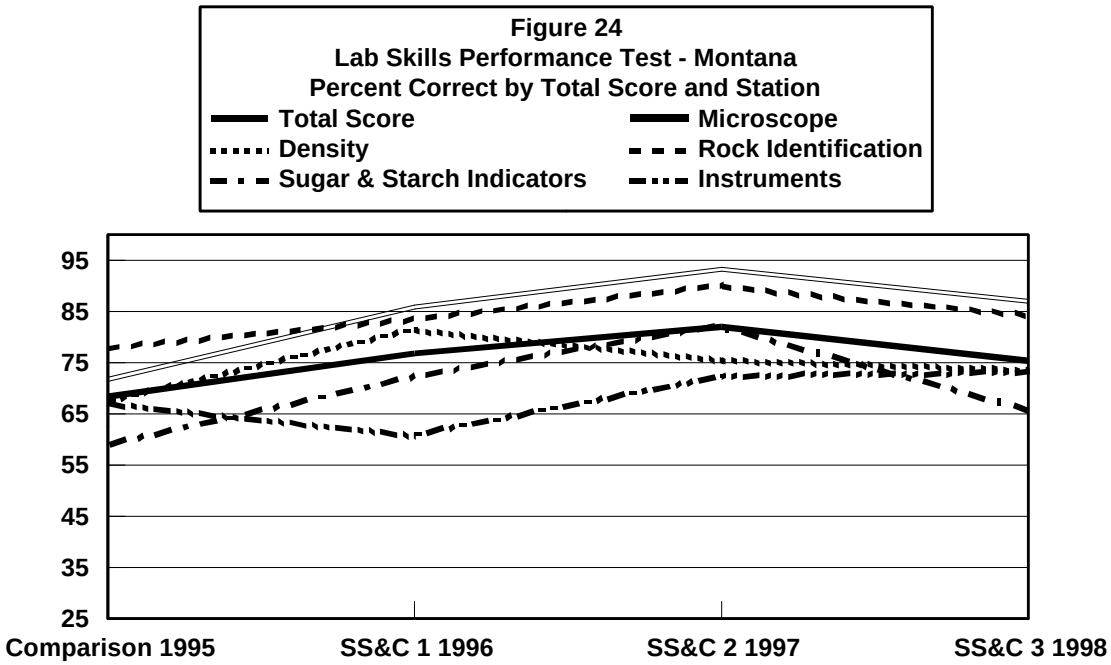
There did appear to be changes in student motivation. Increases were observed in student's perceptions that their science class is motivating, and that they have had a totally awesome science experience. (See Figure 21 and Table 21). No differences were noted in students' attitude toward science. (See Figure 22 and Table 22).



While no significant changes were found in the total score on the multiple-choice science literacy test, in the third year of SS&C there was an increase in physical science and life science scores, but a decrease in earth and space science scores (see Figure 23 and Table 23). Consistent with the more inquiry-oriented learning environment, significant increases were found on the lab skills test during the first and second year of SS&C, and it appears these increases are holding steady into the third year (See Figure 24 and Table 24)

Figure 23
Science Literacy Test - Montana
Percent Correct on NRC Standards





Changes were also observed on the hands-on full investigation test. Students in two of the three SS&C groups scores higher than the comparison group. (See Figure 25 and Table 25) Likewise, SS&C students scored higher on the written full investigation than comparison year students. (See Figure 26 and Table 26). Given the changes on these multiple measures of students' laboratory skills it appears that the more inquiry-oriented science teaching at Montana Junior High School has positively affected students' skills.

The changes in students' lab skills were also noted by the science teachers in Montana. The 10th grade teachers reported that they observed a marked difference in students who took SS&C in 9th grade and those students who did not. During lab activities, the student who took SS&C the year before would dive right into lab activities and were better able to conduct open-ended investigations. The students who did not take 9th grade SS&C were more reluctant to participate and would frequently ask for more detailed instructions about what they were supposed to do.

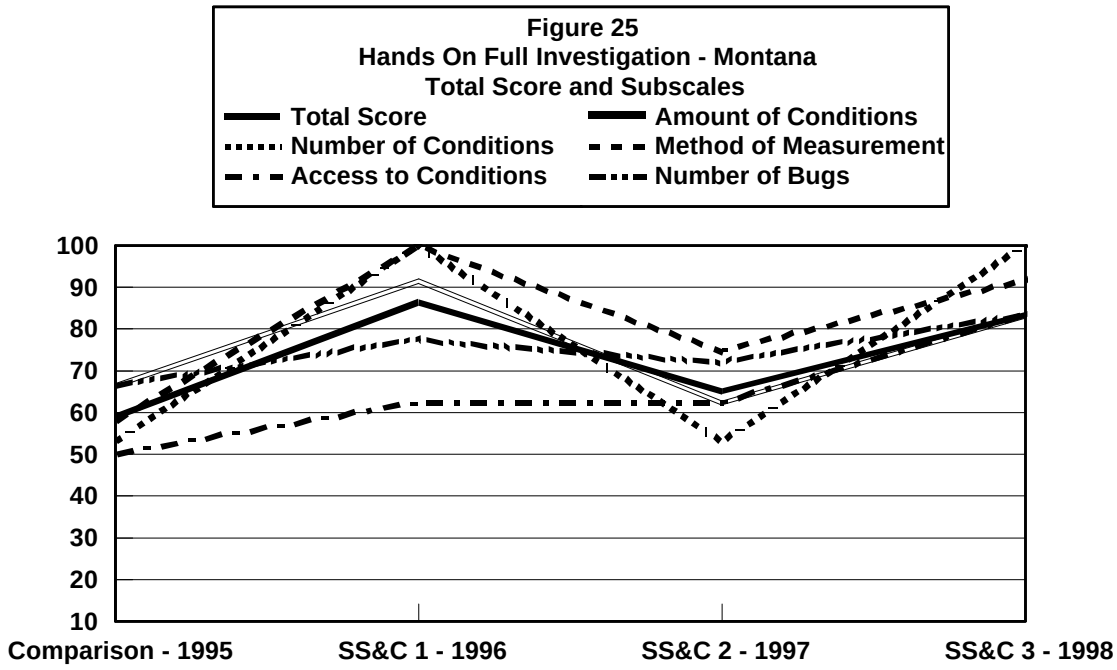


Figure 25
Hands On Full Investigation - Montana
Total Score and Subscales
Total Score
Amount of Conditions
Number of Conditions
Method of Measurement
Access to Conditions
Number of Bugs
100
90
80
70
60
50
40
30
20
10
Comparison - 1995
SS&C 1 - 1996
SS&C 2 - 1997
SS&C 3 - 1998

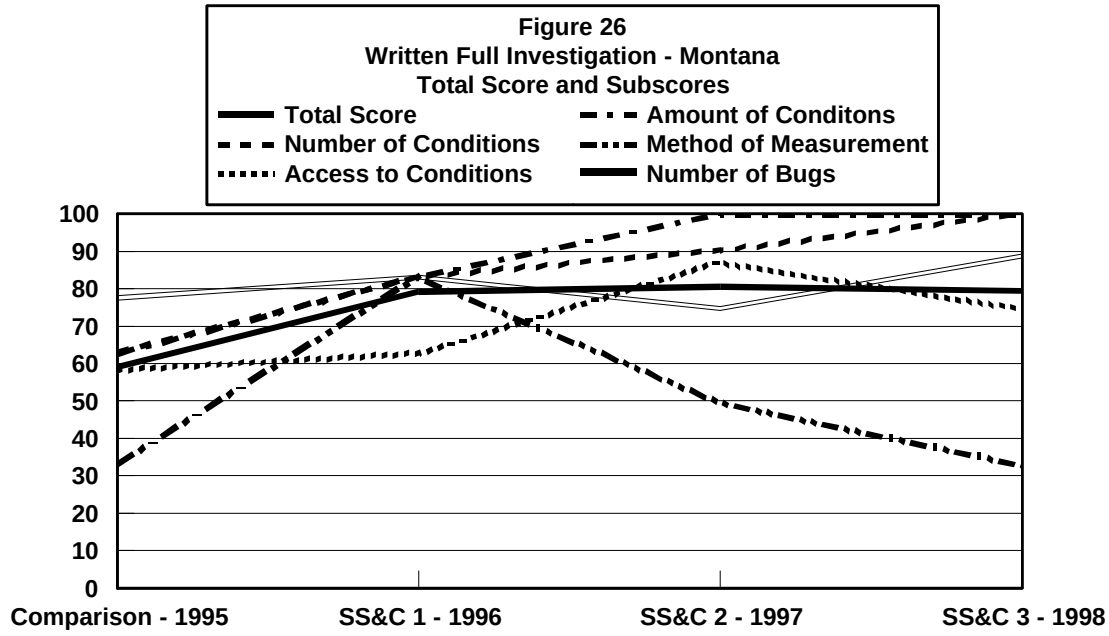


Figure 26
Written Full Investigation - Montana
Total Score and Subscores
Total Score
Amount of Conditons
Number of Conditions
Method of Measurement
Access to Conditions
Number of Bugs
100
90
80
70
60
50
40
30
20
10
0
Comparison - 1995
SS&C 1 - 1996
SS&C 2 - 1997
SS&C 3 - 1998

VII. The Iowa High School Experience

School Setting

Iowa High School offers its students an educational program that will prepare them for post secondary educational opportunities as well as to provide a sound foundation for becoming productive citizens. The high school offers leadership and academic training for students, promotes the learning process, addresses the many needs of students and prepares them to enter the adult world in an everchanging scenario of rapid business and technological change. The school has a high number of students, above 90%, who continue on to post-secondary school opportunities.

The high school is located in the suburbs of a medium-sized Iowa city. The surrounding suburban area consists of moderate sized single homes. There are multi-unit apartments within short distances from the school. New construction of single and multi-units is a common sight in the area. Older, established residential areas are located further away from the school, and in city proper. The community ranges economically from low to upper middle class. The student population is almost entirely white with few African American, Asian and Hispanic/Latino students. The community and the population of the school have been relatively stable over the course of the study. There are several large industries that have been in the community for many years, including John Deere Tractor, which are very active in providing technical and engineering jobs as well as support programs for the schools within the district.

The school is a 30 year old two story brick/cement block building, with a science and math brick/cement block addition that is 10 years old. The school contains an L-shaped floorplan. The building is very clean and neat with large plants greeting the students as they enter the school. Both inside and outside, the building is pleasant to look at and is well maintained. The school is located on a large track of land, which the horticulture class uses as an outdoor classroom. The school site includes a state of the art track and field, and complete athletic facilities, including a swimming pool. The science

classrooms are grouped together in the new addition, located on both the first and second floor. The science teachers have a large classroom with 24 moveable desks in one half and 6 science laboratory stations, with 4 lab stools per lab station in the other half. The laboratory stations are equipped with traditional science equipment such as water and gas. The teacher utilizes both sides of the large classroom, depending on the activity. Often, the class will start in the moveable desk side, move to the laboratory stations for a hands-on activity, then move back to the desks for discussion and closure. The classrooms are all equipped with blackboards, bulletin boards, ample (if there is such a thing) storage space, an overhead projector, and a computer. Students' work is sometimes displayed on one of the bulletin boards. The remaining bulletin boards are covered with teacher prepared displays on various topics, changing periodically throughout the year. The laboratories are reasonably well equipped with most of the major equipment being somewhat old. The teachers purchase consumable supplies and materials as needed for the science program, using science budget funds. Major pieces of equipment are purchased on a need basis.

Science Program

The science program has been slowly changing over the years that we have been collecting data, with a continuous emphasis on writing, problem solving, and mathematics skills. During the first year of data collection, 1994-95, most of the ninth grade students were taking earth science from which they went on to take biology or honors biology. Some students were allowed to enroll in 9th grade biology which would be followed by a 10th grade honors biology. Students are required by the State of Iowa to take two years of science to graduate from high school, but many students choose a minimum of three years of science. The school offered classes in chemistry (Chem Study and regular chemistry), biology I & II, zoology, physiology, horticulture, conceptual physics, and college bound physics for those students who chose to take more science.

SS&C for 9th grade students was implemented in 1995-96 with the 10th grade options remaining the same as the previous year. In 1996-97 and 97-98 SS&C was offered for

both grade 9 and grade 10. In 95-96, 96-97 and 97-98 most grade 9 students were required to take SS&C and most grade 10 students did so as well in the 96-97 and 97-98 years. Some grade 9 students took honors biology moving on to 10th grade biology instead of SS&C those years but only a few sections were offered. Students who took the 9th grade honors biology had to have 8th grade teacher recommendations as well as good grades. The SS&C teachers did have a classroom set of earth science and biology textbooks for the students to use as references. During the first year of SS&C implementation, the school named the course Science Literacy, but the course will be referred to as SS&C for this report.

Through the spring of 1998, students could take biology I (9th grade), biology II, zoology, physiology, horticulture, chemistry or physics after the two years of SS&C (Science Literacy I for grade 9, Science Literacy II for grade 10). There were advanced classes available in biology, chemistry and physics.

During the 1997-98 school year the majority of 9th grade students took SS&C. The current SS&C course is essentially based on the original SS&C project, with biology, chemistry, and earth science all in one course. The teachers have increased the amount of earth science in their version of SS&C for grade nine students. The students do not use a science textbook, but they do use teacher prepared packets, with supplemental readings. There are science texts available for reference. The teachers have a rather broad and general science background, feeling comfortable teaching the biology, chemistry and earth science found in the program. 9th grade SS&C teachers coordinate their lessons to be able to share equipment and supplies, eliminating some of the preparatory time for this course.

During the 1997-98 school year the teachers involved in teaching the 9th grade SS&C course taught approximately 210 students with classes of approximately 24 students. Overall the teachers felt that the course had too much emphasis on biology and not enough emphasis on earth science. One of the teachers had taught science at Iowa High

School prior to implementing the SS&C program, and he felt there were significant differences between the courses in ways other than the curriculum, student interaction as an example. The teacher indicated that there were large differences with respect to the hands on component of the courses and that he believed there was much more time devoted to laboratory work than before. The SS&C course seems to be very similar to the daily hands on activities that were part of the original SS&C program. The interviews with the teachers and the observations indicated that the course was less traditional in that the laboratory activities were often presented prior to the introduction to the concept and vocabulary lists. The laboratory activities were for the most part taken from the original SS&C packets, with modifications made by the teachers over the course of the last three years. The teachers agreed that they used a large portion of the original and modified SS&C materials and they also noted that they had re-ordered the sequence of the packets and activities in order to develop smoother transitions. They also said they have added reading materials as well as increased the emphasis on earth science activities and decreased the emphasis on biology activities.

There have been 7 science teachers in the school each of the data collection years. During the first two years, there were three and four teachers teaching SS&C. The other teachers all taught in their areas of specialty. In 97-98 there were nine SS&C sections offered for approximately 200 students. The SS&C classes were not ability grouped. Class sizes over the years ranged from 18-25. Classes are offered on a 45 minute period schedule.

School Climate

There have been two principals during the period of this study. The current principal was assistant principal for over 10 years at Iowa High School prior to becoming the acting principal. Based on the interviews, both principals appeared to be concerned about providing the students with a quality education, one that prepares them for the diverse opportunities that they will face after leaving Iowa High School. Both principals also appeared to be concerned about enhancing the reputation of the school. The school has

held high standards for academic achievement and is a proud part of the local community. The current principal says he is personally interested in school/parent involvement and attempts to support efforts in that area. He also is very concerned about providing technological and science experiences in order to enhance the students' opportunities after leaving Iowa High School. He is aware of the NRC science standards, but has little personal working knowledge of them. During the interview he stated that he was very comfortable having his science department be responsible for keeping the school's science program in conjunction with the NRC science standards. The district is quite large and very diverse economically. Over the years of this study, both principals' interest in the SS&C courses has basically remained the same, believing that the SS&C program offers a good course for the general student population. They believed that the SS&C courses increased the exposure to science to the students who might not be otherwise interested in taking college prep science courses. Based on the interviews of the principals and the science department teachers, both principals have been supportive of the SS&C project from the outset. Since the funding has been cut, there is still strong support for the 9th grade SS&C program. The new principal and the science department staff believe that they have adapted the original SS&C program to better meet the needs of the students, and are relatively happy with their SS&C courses as they continue to revamp them to better meet the needs of their students.

All of the science teachers are dedicated to make the science experience the best they can for their students. The students are generally polite and behavior problems are few. Attendance rate is above 95%, and students seem to be involved and generally accepting of their school programs. The students are mixed academically and special classes are available. There are a number of opportunities for students at the high end. School pride is outwardly shown by support for athletics and activities outside of school, but academics also seems to be an important activity for many of the students. There does seem to be a general sense that academics are important, which is reinforced by the science teachers in the classrooms. During classroom observations, short "talks" about the expectations of higher education have been noted. The teachers continuously remind

the students that their education is very important, trying to give relevant examples on a regular basis. The attitudes of the students and teachers have stayed much the same over the years.

Science Department Climate

Throughout the years of data collection, the leadership in the department has undergone one major change. The department chair during the first two years of the study has retired. He was department chair for many years prior to and for the first two years of, the SS&C adoption but retired at the end of 1997-98 school year. He was also the main earth science teacher, and it was difficult for him to not teach earth science while having to teach the SS&C course. The new department chair has been on the science staff for 30 years, and all issues including curriculum and equipment are coordinated between the chair and the individual teachers. The SS&C liaison is the science department chair. The current chair strongly believes in SS&C and attended the summer 1996 SS&C workshop in Texas. He has been very supportive of the 9th grade SS&C program.

In the first year of implementation, 1995-6 of SS&C at the grade nine level there were three teachers teaching SS&C. Five teachers had been working with the SS&C project before the summer teacher enhancement effort of 1995 and four of them had provided the project with sample curricular materials. Of the five teachers involved in the project, all but one attended the training in the summer in Montana. There were several staff changes and six teachers had the opportunity to attend the Texas based training provided by the project. The SS&C project was supported by the district in addition to another local rural district. The teachers in the two districts enjoyed limited support from the University of Iowa, during the first two years of data collection. The teachers at Iowa High School had some of their planning periods structured at the same time, in addition to the same lunch period, to provide opportunities to work together on SS&C issues during the school year. All but one of the teachers had more than three years of experience teaching science and they all attempted to implement the SS&C course to the best of their abilities. The implementation of the SS&C courses was accomplished with

varying success by the different teachers, often due to teacher personality, expertise, and philosophical beliefs. All of the teachers were committed to following the curricular materials as best they could and to providing hands on experiences for their students. Not all teachers of the SS&C courses felt that they had enough training to effectively teach the course as it was intended to be taught. In the teacher interviews, it was often and emphatically stated that they would benefit from having additional training and proper support throughout the implementation process.

In the 1996-7 year the summer workshop for training SS&C grade 10 teachers nationally was held at Texas High School. Two of the 9th grade teachers and three of the 10th grade teachers attended the general sessions. Although the teachers this year had both their lunch and some of their planning periods coordinated so they could work on the SS&C course, there was no ongoing external professional development because the grant had not been renewed. There were about 20 sections of SS&C offered, since it was the standard science program for the majority of grade 9 and 10 students. In the 1996-7 year there were three teachers for grade 9 and three teachers for grade 10 with some teachers teaching mixed preparations. The teachers were a mix of experienced teachers, with one teacher with 2 years of experience. The SS&C liaison, who also was the department chair, encouraged dialog within the department concerning SS&C and supported the implementation effort. The teachers tried to follow the curricular materials but at the grade 9 level they were making changes based on their previous years' experience. The teachers of the grade 10 SS&C course had the most trouble implementing the materials. The main problem was lack of printed packets, which hindered effective planning, resulting in a negative effect on teacher delivery and teacher morale. Advanced planning was critical for these experienced teachers and the lack of lead time for planning created severe morale problems and was a constant source of contention and disdain during the interviews. In addition, one of the 10th grade teachers struggled with teaching out of her content specialty, even though she was highly respected in her specialty. During the interviews she indicated that she spent an inordinate amount of prep time to bring herself up to a subject knowledge level that would satisfy her high expectations. She indicated

during the teacher interviews that she honestly felt the pressures of a first year teacher, even though she had more than 23 years of experience in a science classroom.

In 1997-98 there were two teachers teaching grade 9 SS&C and they both had strong teaching skills, and good rapport with the students. Both teachers were career teachers and one had been teaching SS&C since the program began at Iowa High School. The other teacher was new to Iowa High School in the 1996-7 year, but had taught an active hands on science class in another district for five years. Both teachers were using the site modified SS&C curricular materials. Both teachers have similar years of experience but implement the SS&C courses with a decidedly individual bias, mainly based on their personalities. They both have agreed upon the changes and additions made to the program, since they have been given full control of how and what changes are made. The two 9th grade teachers have committed to the basic premise of having the students experience the hands on activity prior to introducing the concept, and of having the students discuss results. However, they do not allow the students to be responsible for their own learning on a regular basis. They both agree that being responsible is a great goal, but that very often the students are simply not ready for that step, resulting in few opportunities for the students to do so.

Curriculum, Instruction and Assessment

Throughout the data collection period the teachers have generally agreed that the students are receiving an appropriate amount of hands on experience, but are lacking in content reading material. For example, although the teachers felt that concepts covered in grade 9 SS&C were for the most part appropriate, three of the teachers felt that their students wouldn't be able to understand the concepts without additional supplemental reading materials and additional time spent on a more traditional method of teaching, specifically direct instruction. At first the majority of the teachers did not feel that the ninth graders were ready for the responsibilities of a SS&C type program, but over the data collection period, the teachers have changed their views somewhat, and now believe that their grade 9 students, for the most part, handle parts of the independence quite well. It must be

noted, however, that the current 9th grade SS&C teachers do not allow students very much latitude or decision making as far as experiment design. Without some modifications to the presentation of the SS&C materials, the teachers also believed that the students would have difficulty understanding the content without teacher directed discussions following the activities and some use of direct instruction. The teachers generally felt that they needed to provide more direction and theory or, in other words, the students needed more guidance through the curriculum than what was first proposed for the SS&C program. The teachers were reluctant to let the students have too much responsibility and flexibility in experimentation. This led to more teacher direction in the classes than what they believed was recommended by the SS&C project. According to teacher interviews, the imposition of teacher directions has steadily decreased over the past two years. This decrease was largely due to the two grade 9 teachers believing in the overall philosophy of the SS&C program and believing that the changes and additions made to the original SS&C curriculum had sufficiently addressed their original concerns. They are currently quite satisfied with the direction that the course has taken and the apparent ability of their students to handle hands on activities with little direct instruction. The teachers honestly believe that their SS&C students are better able to complete hands on activities.

The teaching in the 1994-95 year was very traditional and has continued to have some traditional flavor despite the changes forced by the SS&C project's emphasis on hands on activities and no textbook. The most significant changes toward adopting a more hands-on approach with some emphasis on inquiry showed up in the 1996-7 year when the two current grade 9 teachers were responsible for all grade 9 SS&C courses. Both grade nine SS&C teachers were very committed to the philosophy of SS&C, and feeling that the changes that they still could make to the course would continue to improve the program. This commitment has continued to be strong, and for the 1998 data collection year, the teachers continued to believe that the hands on approach was effective and beneficial to their students.

During the first two years of data collection, the students, for the most part, were not encouraged or expected to deviate from the set activity. Most of the teachers believed the students needed guidance and that they were not ready to accept the responsibility of thinking on their own or designing their own investigations. That belief has changed somewhat, there has been an evolution of what the teachers expect the student to know, including fewer facts and more conceptual understanding of the material presented in the hands on activities. The current grade 9 teachers believe that they are giving the students more opportunities to experiment in new and different ways. This has not been observed in the classroom observations, but has been noted in the teacher interviews and general discussions during the site visits. During the first year of data collection, the teachers' general approach to teaching was to help the students prepare for college. This general view among the science teachers that only higher education would provide a way to better the students' lives is not as prevalent in the two current grade 9 teachers. The current grade 9 teachers express equal concern for the student who may not advance to study at the university level. There was a sense of a lack of strong content material during the first two years of implementation, but the current grade 9 teachers both believe that the hands on experience which the SS&C course provides is consistent with what they believe the students need to prepare themselves not only for post secondary education, but for basic life skills. Both grade nine teachers believe that the students are better able to explain why certain things happen and are also better equipped to solve problems.

Teacher Enhancement

Most of the teachers at the school had the opportunity to participate in the training supported by the original grant project. A total of four teachers had the opportunity to participate in both of the summer institutes. Three teachers also wrote some of the curricular materials the first year. One of these teachers presently teaches grade 9 SS&C. One of the original teachers who participated in both of the training sessions also was the department chair, and has since retired. Two teachers, who presently teach grade 10 SS&C, participated in the second summer training session. Two of the teachers who

participated in both summer institutes do not presently teach SS&C courses, one of those teachers is currently the department chair.

There has been a very real lack of any on site training in SS&C other than the distribution of the materials, which the teachers would indicate were not distributed in a timely manner. As a result, new teachers to the system would not receive any formal SS&C training. All new teachers have learned about the SS&C project through relationships within the science department and through shared planning periods and lunch periods. In previous years the SS&C teachers had some of their free periods, as well as all lunch periods, scheduled at the same time so that they could have joint planning sessions. This was not the case in the 97-98 year and so any joint planning had to be done after school or during lunch. In the summer of 1997 there was a two week planning period allowed for both the grade 9 and the grade 10 SS&C teachers to revamp and organize their curriculum materials. All but one of the grade 10 staff attended. Both of the current grade 9 teachers have indicated in their most recent interviews that they would greatly benefit from a joint school sharing of ideas among existing SS&C teachers, in the form of workshops and other means of communication.

Analysis

Over the four years of the SS&C project, the school and the science department remained quite stable. The previous and current science department chair and at least three of the other science teachers were strongly committed to and involved with the teacher enhancement and curricular development efforts. This commitment has continued for the entire four years. As a result of this stability and consistency, changes found can be attributed to the SS&C curriculum.

The project at Iowa High School began very positively. The teachers had been previously involved in curriculum development with Dr. Robert Yeager, who had been operating other projects (mostly related to science, technology and society) in the district and state. The curricular specialist for the district and the school principal were behind

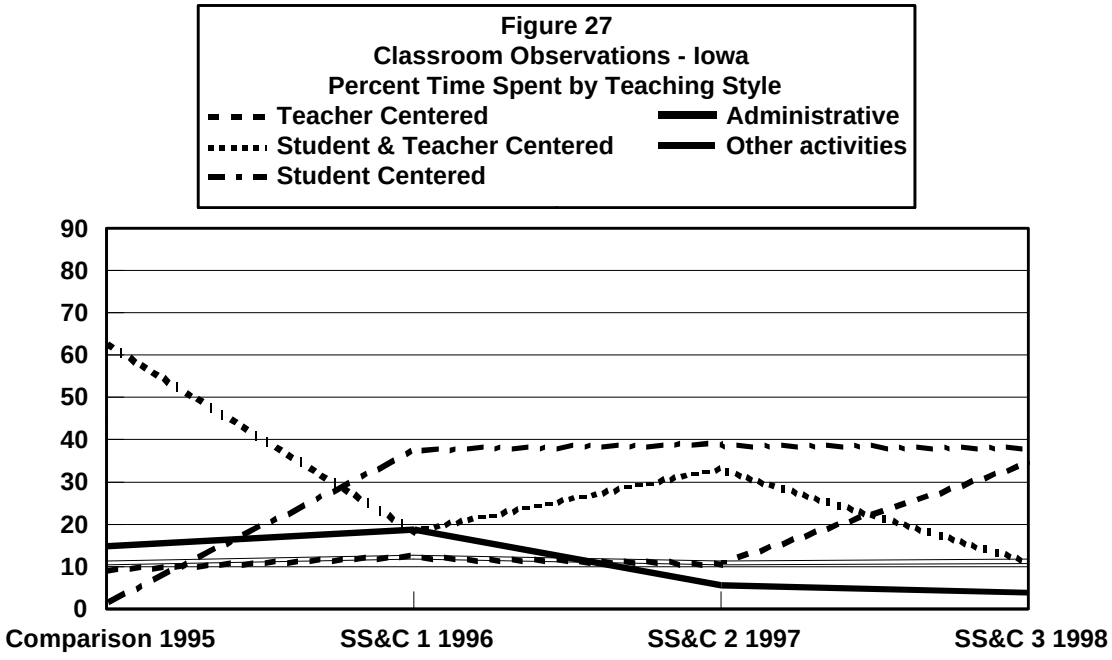
the project. Five teachers attended the first summer enhancement program in MT for the grade 9 curriculum and semi regular meetings of the teachers from IA schools were held. The decision to continue after national funding stopped was greatly influenced by the belief and commitment of the department chair, as well as the grade 9 and10 SS&C teachers. They believed that the effort put forth had provided the school with a workable science program, however, they also believed that continued modification of the course materials was necessary to make it more effective.

The 97-98 year showed a continuation of the commitment of the 96-97 year. The science department staff, overall, believed that the existing SS&C courses were an improvement to the science program that they replaced and that the courses offered a valuable experience for many of their students.

The changes in the science department seemed to have little if any effect on the implementation of the SS&C courses. The former chair was committed to providing a strong science program, but he did have trouble, personally, implementing the SS&C teaching methods. The new department chair had also attended the SS&C training but did not teach the 9^{th} grade. He strongly believed that SS&C was a good way to proceed, but had little practical experience with the methods. In a recent interview, the department chair indicated that they were looking into developing a form of 11th grade chemistry that included some aspects of the SS&C philosophy.

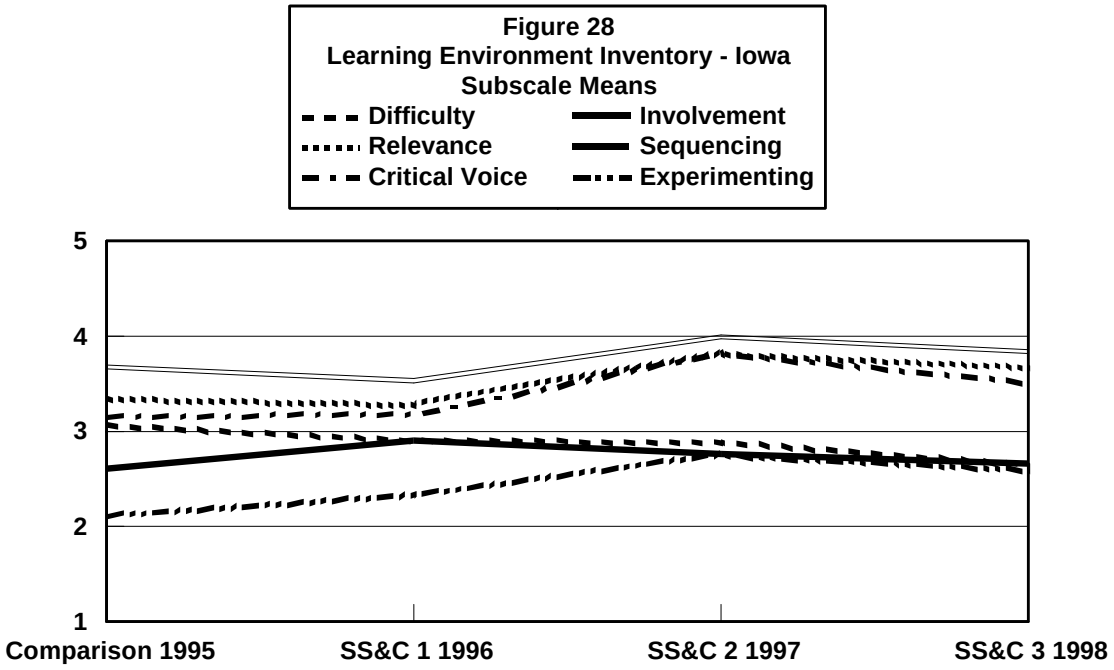
The SS&C program required a large increase in preparation time. The experienced teachers reported they felt like first year teachers again, and for the ones with 25 plus years of experience, that was a major concern. The SS&C program also required that the teachers be able to teach in an inquiry fashion. At Iowa High School there was only one new teacher teaching SS&C, but all were new to the idea of inquiry teaching. The labs were well stocked, but to do SS&C effectively the teachers have to plan well in advance to purchase many of the consumable supplies, and to construct some of the apparatus needed for the activities. There was little teacher training to assist the teachers in

developing creative ways to implement the inquiry, hands on activities. This may have led to a less complete implementation of the curriculum. The teachers did not use inquiry, hands on learning as much as the SS&C program dictated. The elimination of funding resulted in no national goals or outcomes that had to be met, so the teachers' own goals and outcomes became the driving force behind continuing the SS&C program. As a result, the classes had less student centered activity and more teacher centered activity than might have been considered optimal.



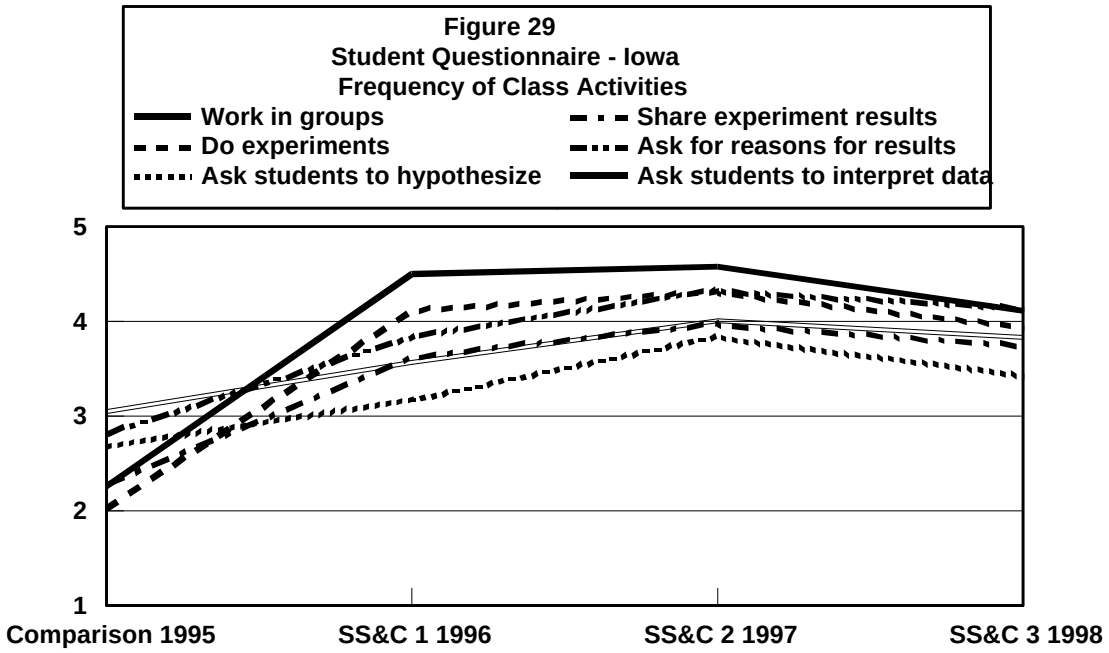
The results of the classroom observations show that the classroom became significantly more student centered (See Figure 27 and Table 27). Teacher centered behaviors remained about the same until 1998, showing a rather dramatic increase in percent time spent, increasing from near 10% to more than 40%. The amount of time spent on student & teacher centered activities decreased, starting at more than 60% and ending at 10% for the 1998 collection year. The percent time spent doing student centered activities increased from less than 10% of the time to almost 40% of the time during the first year of SS&C implementation and remained fairly steady for the remaining two years of data

collection. The amount of time spent on administrative tasks remained relatively stable for all of the years that data was collected, and the other activities category increased slightly during the first year of SS&C implementation and then decreased to zero during the 1998 collection year.



The results of the learning environment inventory included six subscales. (See Figure 28 and Table 28). The Difficulty subscale showed a slight but consistent drop throughout the period of data collection becoming significantly different from the comparison year by 1998. Relevance stayed consistent for the first year of SS&C implementation, but significantly increased from the comparison year for the second year and remained high. Both the critical voice and experimenting subscale scores showed increases during both the first and second year of SS&C implementation, with slight decreases during the third year. Critical voice was significantly higher than the comparison year in 1997 and 1998 and experimenting was significantly higher all three years. The sequencing subscale showed a significant increase during the first year of SS&C implementation, but decreased to the level of the comparison year for the remaining two years. The

involvement subscale showed a slight decrease during the first implementation year, followed by a significant increase during the second year of SS&C which remained for 1998.



The results of the student questionnaire show significant changes in classroom activities toward a more student centered environment. (See Figure 29, 30 & 31 and Table 29, 30 & 31). There were significant increases that remained all three years for working in groups, doing experiments, asking students to hypothesize, sharing experimental results, asking reasons for results, asking students to interpret data, working on projects, reading science articles and other science materials, and doing oral and written reports. There were significant decreases that remained for all three years in reading science texts, in lecturing and in watching films, slides or videos. Going outside for instruction showed a significant increase the first two years of SS&C but then decreased to the level of the comparison year. The two remaining activities showed significant increases only for 1997.

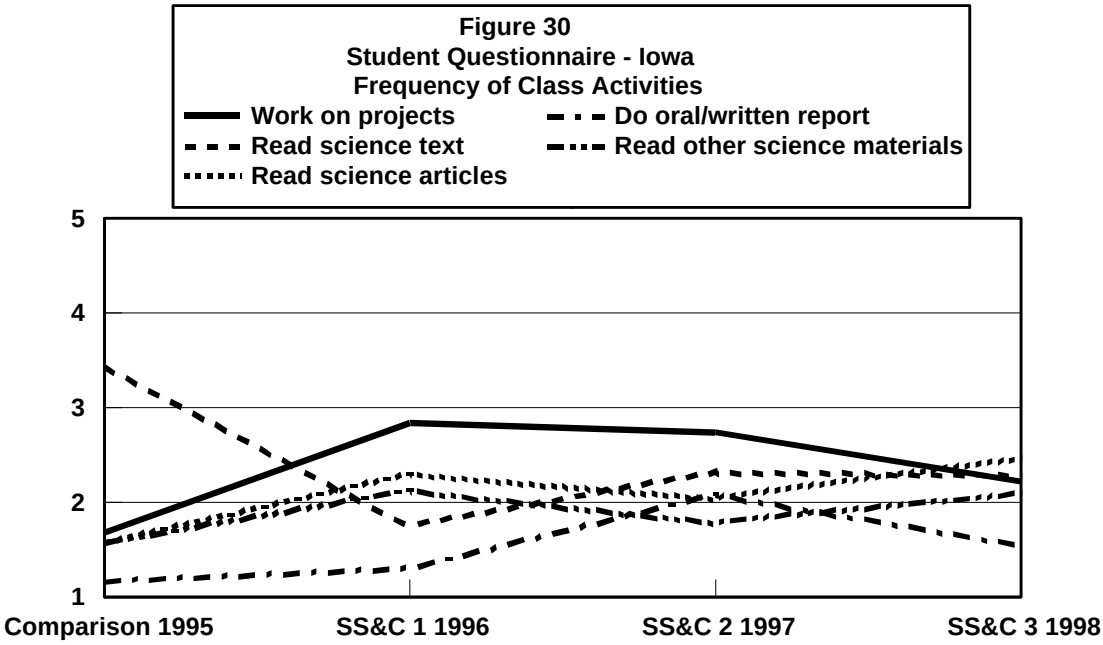


Figure 30
Student Questionnaire - Iowa
Frequency of Class Activities
Work on projects
Do oral/written report
Read science text
Read other science materials
Read science articles
5
4
3
2
1
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998

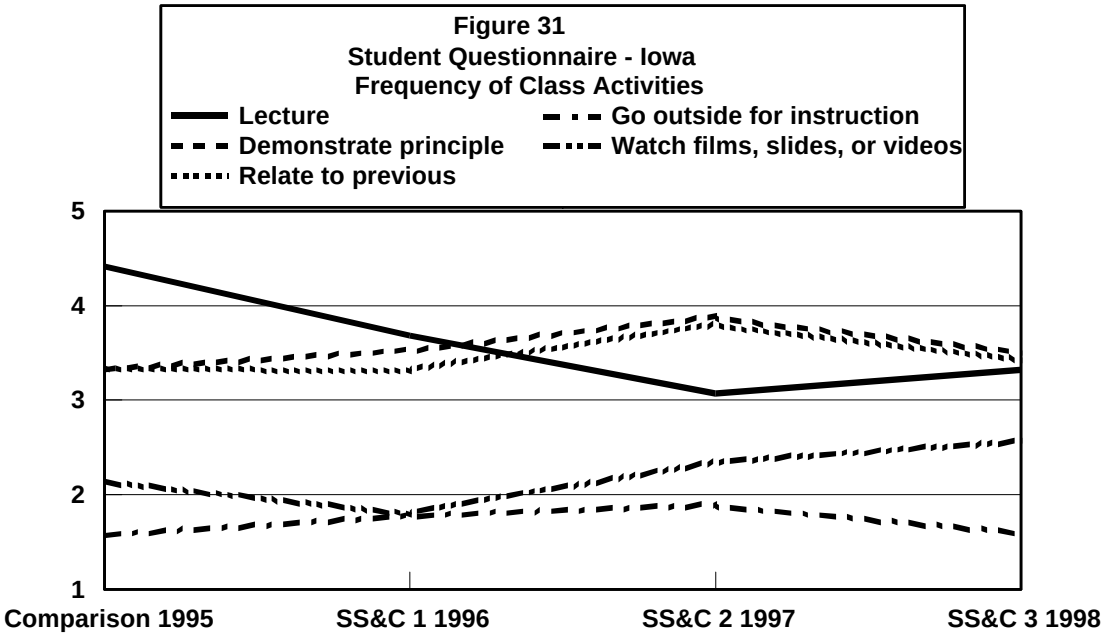
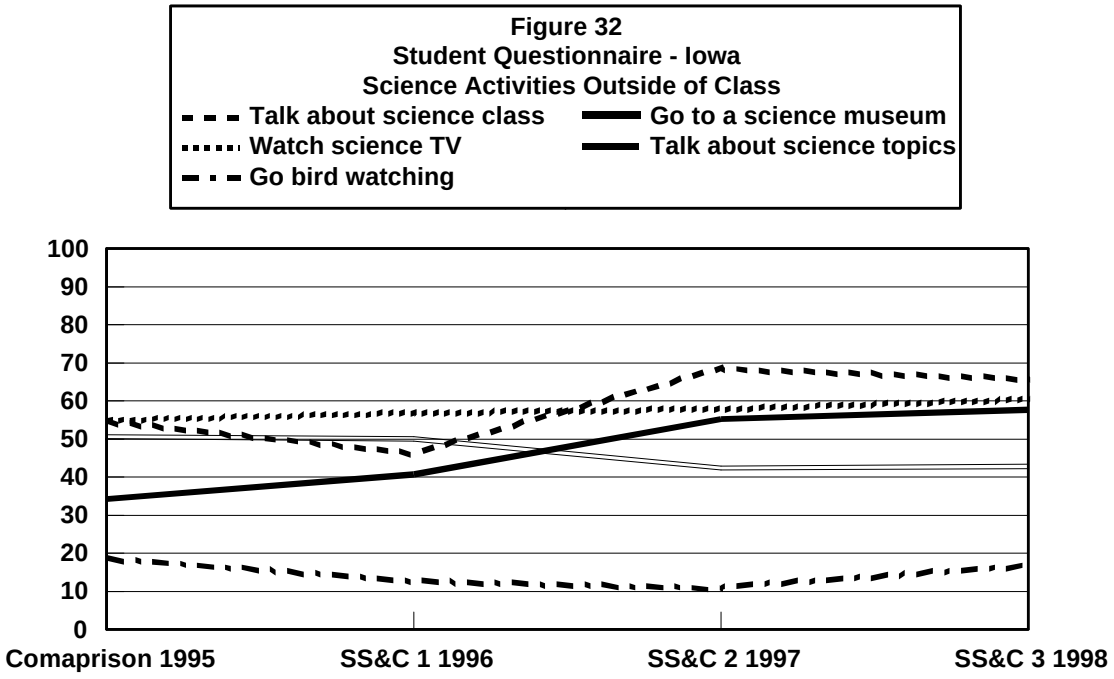


Figure 31
Student Questionnaire - Iowa
Frequency of Class Activities
Lecture
Go outside for instruction
Demonstrate principle
Watch films, slides, or videos
Relate to previous
5
4
3
2
1
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998

The only significant increases for science activities outside of class were talking about science class in 1997 and 1998 (.07), talking about science topics in 1997 and 1998 and in writing a journal article in 1996. Categories of science activities outside of the classroom; watch science TV and talk about science topics showed consistent increases during each of the SS&C implementation data collection years. Two of the categories, go bird watching and go to science museum, both showed overall decreases when compared to the 1995 comparison year. The talk about science class category showed an initial decrease during the first SS&C implementation year, followed by an increase the following year, with a slight decrease during the third, 1998, year. The category, do a science experiment, had a slight increase during the first year of SS&C implementation, but over the next two years of implementation, the results showed a steady decrease. (See Figure 32 and Table 32).



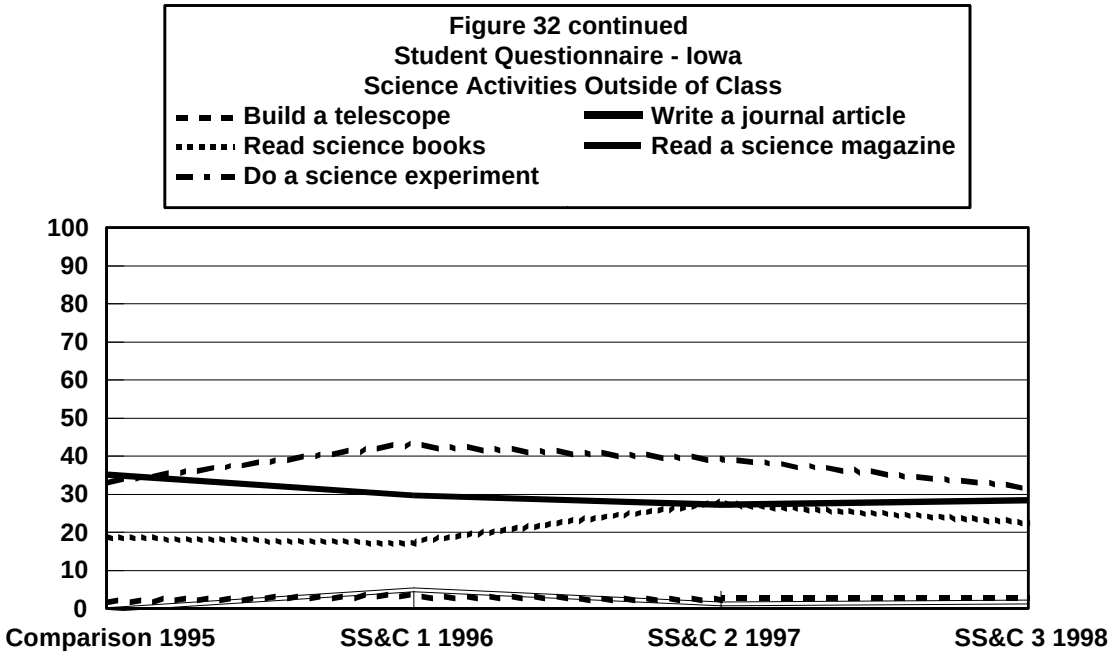
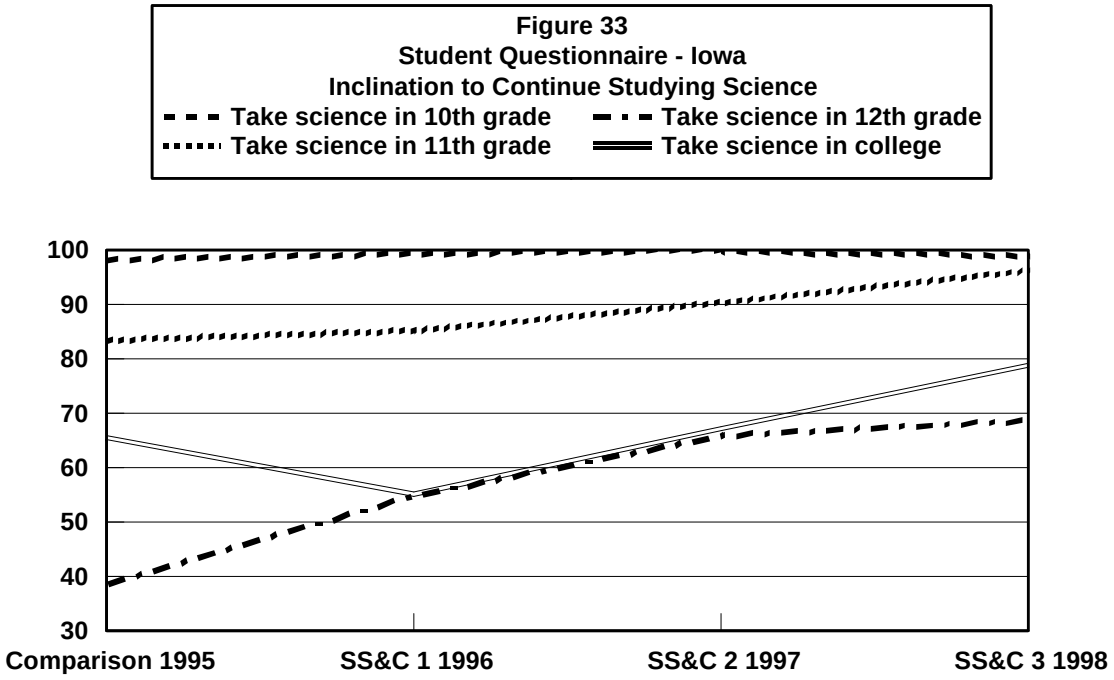
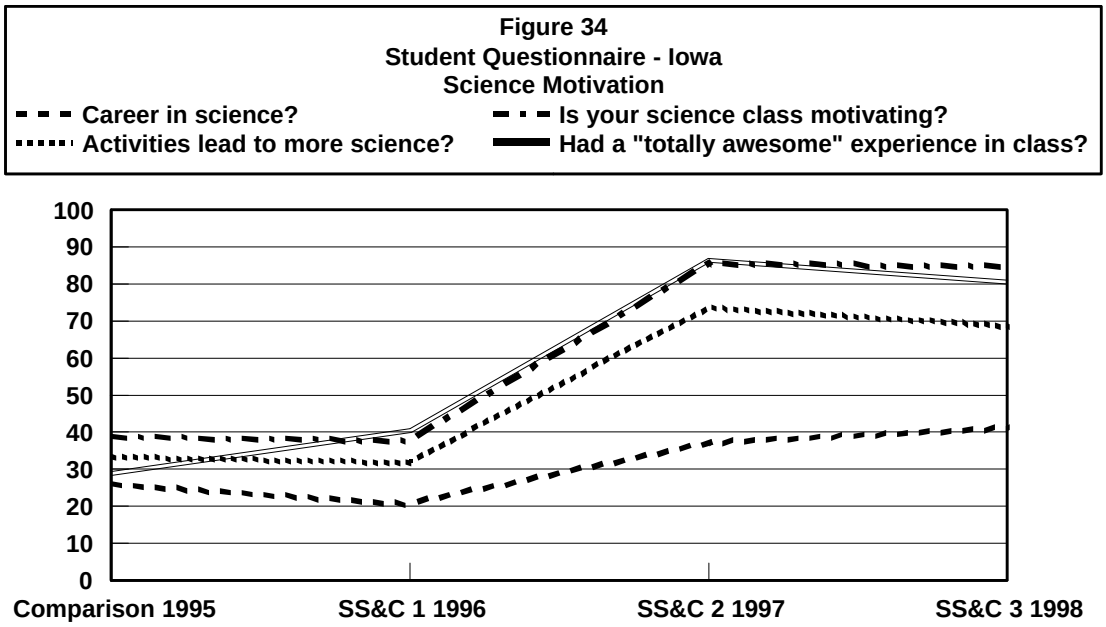


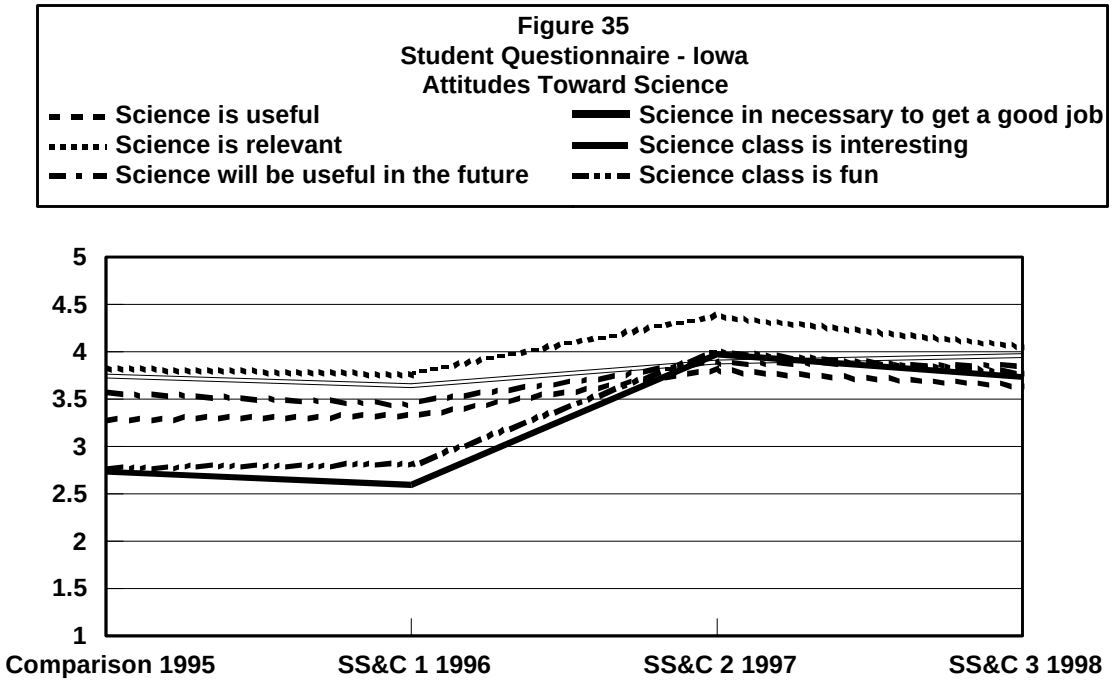
Figure 32 continued
Student Questionnaire - Iowa
Science Activities Outside of Class
Build a telescope
Write a journal article
Read science books
Read a science magazine
Do a science experiment
100
90
80
70
60
50
40
30
20
10
0
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998



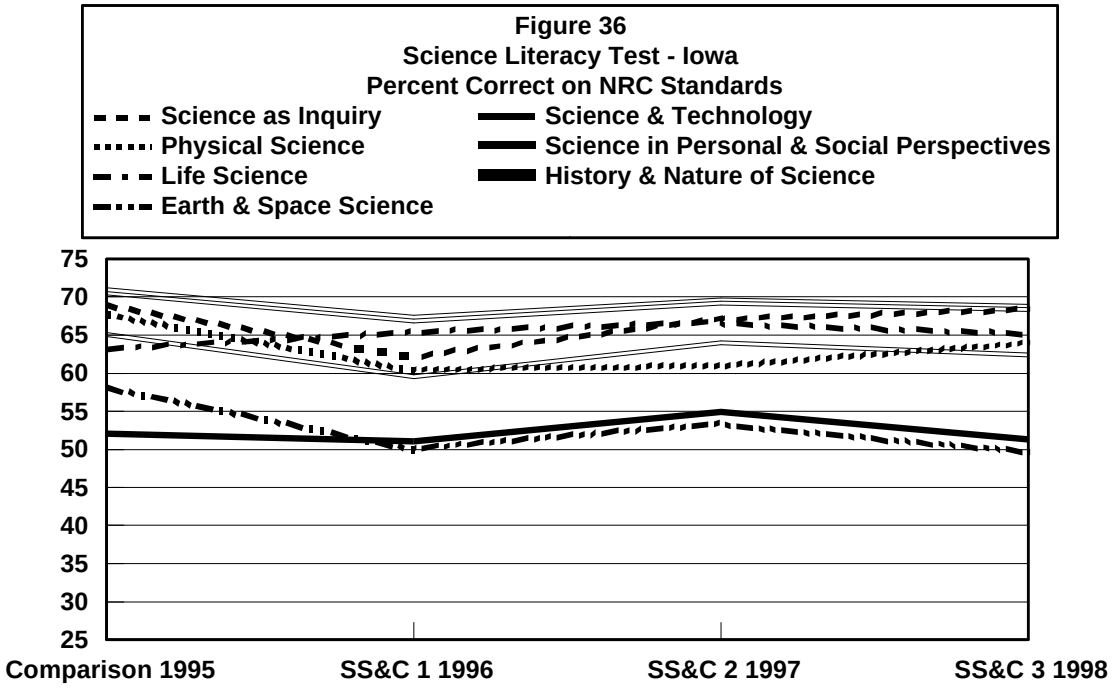
On questions about students' intent to study science in the future, the trend results show that all four categories increased over the three years of SS&C implementation when compared to the 1995 comparison year. (See Figure 33 and Table 33). The category, take science in college, showed a decrease during the first year of SS&C implementation, but increased the following two years. The other three categories, including; Take science in 10th grade, Take science in 11th grade, and Take science in 12th grade, all showed consistent increases during each year of the SS&C implementation. The increases in taking science in 12^{th} grade were significantly different from the comparison year all three years of SS&C and taking science in 11^{th} grade was significantly different from the comparison year by 1998.



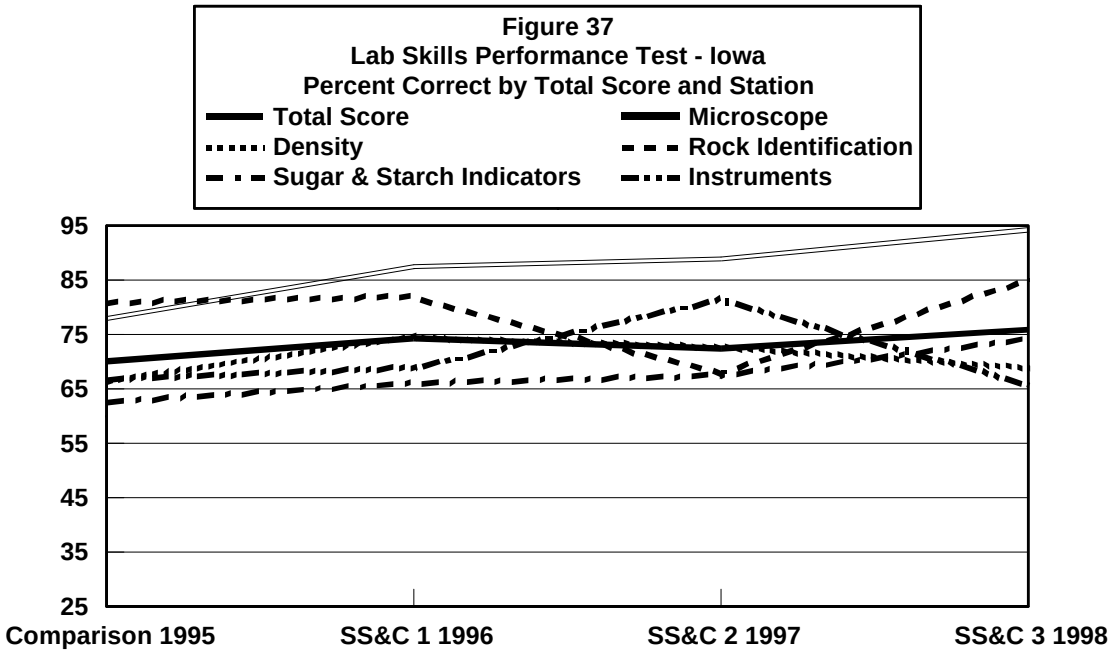
On questions about science motivation, the categories, Activities lead to more science and Career in Science, showed slight decreases during the first year of SS&C implementation but showed significant increases for 1997 and 1998. (See Figure 34 and Table 34). The category, Is your science class motivating, did not show any change during the first year of SS&C implementation, but did show a significant increase during the following collection year and remained at the level for the 1998 collection year. The category, Had a totally awesome experience in class, was the only motivation category to show a significant increase during the first year of SS&C implementation which was maintained through the next two years.



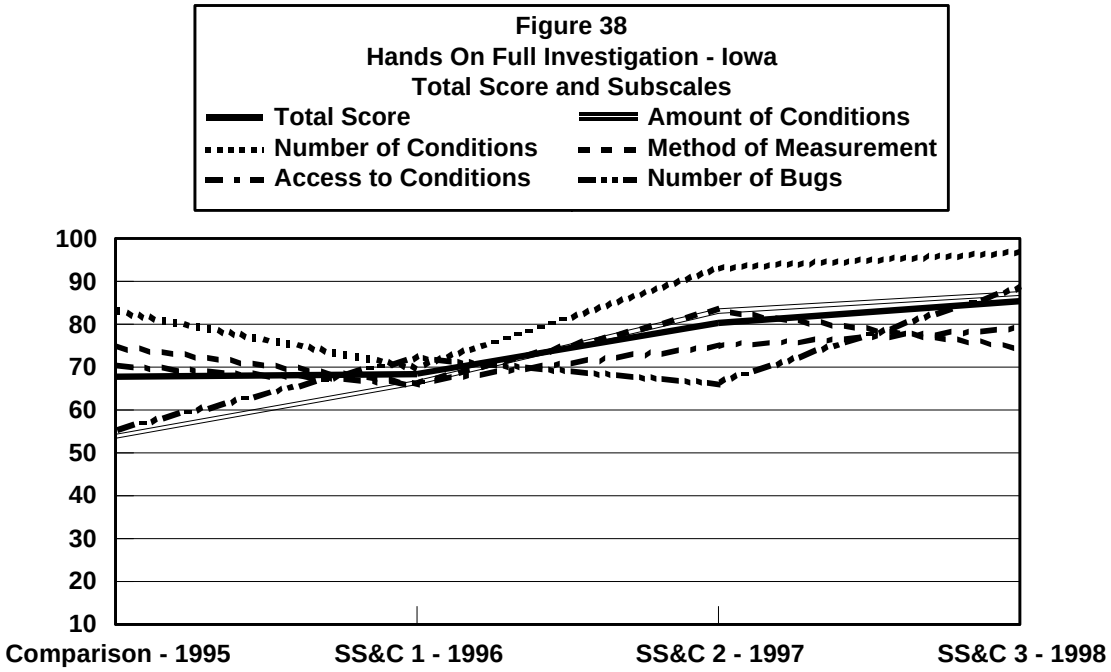
In general all six attitude items showed little increase or even slight decreases during the first year of the SS&C implementation. (See Figure 35 and Table 35). However, during the following collection year all six items showed increases with five of them significantly so. For the third year of SS&C implementation, all items except Science is necessary to get a good job decreased slightly. The science is necessary to get a good job item became significantly different from the comparison year in 1998. All of the remaining items except science is relevant remained significantly higher than the comparison year.



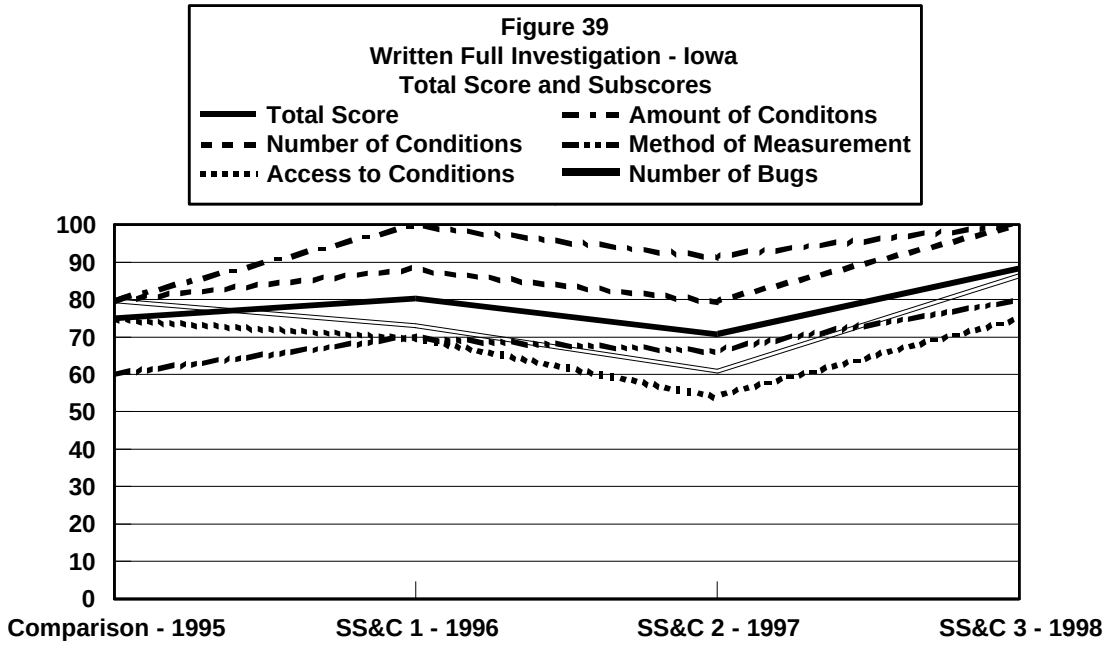
The total score showed a significant drop from the comparison year in 1996, up to comparison year levels in 1997 and then significantly down again in 1998. (See Figure 36 and Table 36). The scores decreased or stayed the same for six of the seven areas tested during the first year of SS&C implementation. Five of the decreases were to levels significantly below that of the comparison year. The only score to increase at all during the first year of SS&C implementation was life science. In 1997 physical science and earth and space science remained significantly below the comparison year but life science was significantly higher. The 97-98 data show increased scores for science as inquiry, physical science (still significantly below the comparison year), science in personal & social perspectives, and the history & nature of science.



The scores on the Lab Skills test for the first year of implementation all increased from the comparison year but no increases were significant. (See Figure 37 and Table 37). The total score on the lab skills test decreased slightly during the second year of SS&C implementation, but increased again during the 1998 data collection year to an almost (.08) significantly higher level than during the comparison year. The score for the rock identification test significantly decreased during the second year of implementation, but increased back to comparison year levels by 1998. The score for the density test increased during the first year of SS&C implementation, but decreased over the second and third year of data collection. The test scores for the instruments test showed a significant increase during the second year of SS&C data collection, but decreased back to comparison year levels during the 1998 collection. Both the sugar & starch indicators and the microscope test scores showed steady increase over all three SS&C data collection years with the change in microscopes significant during the 1997 year.



The overall total score for the Full Investigation test after three years of SS&C was very similar to the overall score during the comparison year with only one significant difference on the number of bugs in 1998. (See Figure 38 and Table 38). During the first year of SS&C implementation, scores for the number of conditions, access to conditions, method of measurement, and the total score all decreased. These same test scores all increased during the second year of SS&C implementation data collection, followed by a decrease during the 1998 (third year of SS&C) data collection year for both the total score and the score for method of measurement. Following the initial decrease during the first year of SS&C implementation for the number of conditions and access to conditions test scores, they both increased during the 1997 and 1998 collection years. Both the amount of conditions and the number of bugs test scores increased during the first year of SS&C implementation. The number of bugs category showed a slight decrease in scores during the second year of implementation, but again showed an increase during the 1998 year. Only the test for the amount of conditions showed a consistent steady increase over all three implementation years.



Although the scores on the written full investigation show increases, none of them were statistically significant. (See Figure 39 and Table 39).

Concluding Remarks

Overall science achievement shows a decrease for the first year of SS&C, then an increase in the second year. This may have been because the teachers were frustrated with trying to implement the new SS&C program the first year. Also of note, each teacher, during the teacher interviews, had predicted that the 1996 (first SS&C) year students were "tagged" as a problem class as a whole, by the 6,7 and 8th grade teachers. The second year the teachers may have been more comfortable with the SS&C program and had made adjustments from the first year. For the 97-98 year the scores go down slightly to near pre SS&C levels. This may reflect the teachers' emphasis on the hands on process rather than specific facts. The decrease in student achievement in the first year is accompanied by a decrease in student & teacher centered teaching behaviors and an increase in the student centered teaching behaviors for the 96 year. The 97 year shows a steady state of the student centered behaviors with a slight drop off by 1998. One interpretation is that the teachers were succeeding in implementing the SS&C program

consistently as it should be in a student centered manner. Even though the student centered emphasis was maintained, the scores did not increase for the literacy tests, but the attitude and motivation of the students showed a steady increase. The teachers report that the students are better prepared to do hands on experiences and are better able to discuss the results of their experiences. By the 1998 year, the teachers were doing what they wanted to do and were comfortable in a more student centered approach. The students' scores however went down slightly but not to the levels of when the teachers were implementing the SS&C style during the first year

It is interesting to note that both grade 9 teachers strongly believe that they now have a course, based on the original SS&C project, which is serving the students better, even if the scores do not show increases in the literacy tests. The students do show big gains in attitude, lab skills, problem solving and discussion skills. According to teacher interviews, both teachers stated that the students are better off now than they were prior to implementation to SS&C.

The California High School Experience

School Setting

California High School is a large, high school located in an urban area with approximately 500,000 people. The city supports a mix of professional and industrial businesses including jobs in finance, banking, and industry. The student population at California High School is quite diverse. In fact, it's one of the few schools where you can find approximately equal numbers of white, black, Hispanic and Asian students all in the same class. The majority students at the school come from low income, working class families. The school suffers from many of the same problems found in urban high schools across the country, namely, overcrowding, lack of building maintenance, and a student population that is largely unmotivated about learning. The school includes a large sprawling campus with old concrete building. Because of over-crowding problems (over 2,000 students), temporary classrooms have been constructed near the football field. The buildings appear run-down, dirty, and in need of regular maintenance. Some of the windows are broken, and graffiti can be found on many buildings.

Science Program

Overall, the science department is extremely hard working and motivated about helping kids learn. The principal said the science department is one of the best departments in the school and he is quite impressed by their commitment and desire to make their classes better. California converted all of their 9th and 10th grade science classes from physical science and biology, respectively, to SS&C. They converted to SS&C for several reasons; most of their students only take the required two years of science and teaching every science every year was a way to expose students to more than just physical science and biology. The staff also believes that all of the sciences are inter-related and should be taught together to properly represent reality. The staff found the inquiry-oriented approach appealing because so many of their students were bored with the traditional, lecture-oriented approach. Before SS&C approximately 40% of the students were failing

9th grade science, and they adopted the SS&C approach as a way to help more students pass science.

At California High School there are six class periods during the day, each lasting 50 minutes. They have approximately 20 classes of 9th grade science with approximately 25 to 30 students per class. These classes are taught by six or seven different teachers. Four of the teachers have been at the school for more than 15 years, and these four teachers taught 9th grade during the comparison year and have taught SS&C science each year. The other two or three 9th grade teaching slots has seen a lot of turnover. In each year there has been at least one new teacher teaching SS&C. These teachers have taught at California for one or two years and then left. The short-term teacher and turnover issues appear to affect both the comparison year and all subsequent SS&C years.

Prior to SS&C the science department offered a typical layer-caked science curriculum. Students were required to take physical science in ninth grade and biology in the tenth grade. The state of California requires two years of science and most students merely fulfill this requirement with these two courses. The science classrooms are organized around a central office area, however, a couple of classes were offered in a temporary building near the football field. Teachers in these classes have to bring lab supplies from the science storage room out to their temporary classes making hands-on science very cumbersome. Space is at a premium and there is very little storage space for science materials. Half of the science classrooms have lab facilities including running water, however, the rest of the science classes are offered in rooms without lab facilities. The lack of materials and the lack of lab facilities make hands-on science very difficult. There are no tracking arrangements in science at California High School except for three sections of second-language science. These classes are offered for students whose primary language is different then English or who have limited English proficiency.

School Climate

California High School is a large, urban school with many of the same problems that one finds in other urban schools around the country. Based upon interviews with the principal, the high school struggles with issues of overcrowding, lack of resources, student absenteeism, and discipline. Most students are not college-bound and do not appear to put a lot of effort into their school work. Security at the school is tight. The grounds are surrounded by wire fencing and police presence in the building is quite evident. Teachers watch the halls closely during passing periods and are always on the alert for trouble. Despite the tight security, the staff is friendly and welcoming. Academically, the school has quite a challenge. The student population is largely non-college bound and rather unmotivated about learning. It is a daily struggle to engage the students in learning, keep them on task, and get them to turn in assignments. Many students are barely passing their classes.

The principal at California High School is very supportive of SS&C. As he said during interviews, the science department is one of his best departments. He's proud that they are striving to improve their science instruction and he is very supportive of their collaborations on SS&C. On the other hand, he was disappointed by the low science test scores and the number of students that fail 9th grade science.

Science Department Climate

The science department climate is very positive. The teachers appear very committed to helping a difficult student body. They regularly arrive at school early and stay late into the afternoon. They are constantly meeting with each other to discuss lab activities and modify the science curriculum. During the implementation of SS&C this core group of 9th grade teachers worked long hours gathering materials, modifying lab activities to fit their equipment, and discuss changes after trying out activities. These teachers are clearly committed to implementing SS&C as fully and completely as possible.

The only caveat to the 9th grade teachers' commitment to SS&C is the striking lack of commitment by the 10th grade teachers. There was a divide between 9th and 10th grade teachers. The majority of 10th grade teachers wanted to stick with the traditional layer-cake curriculum, meaning that they would continue to teach biology at the 10th grade. They were very resistant to SS&C and for the most part did not support SS&C at the 10th grade. The different views on SS&C caused some tension in the department. As a result the 9th grade teachers were on their own to implement SS&C with only lukewarm support from their colleagues. The other troubling spot in the science department climate is a tenured teacher who cannot be removed but is viewed by the department as somewhat incompetent. This teacher does not use the SS&C philosophy, but instead simply lectures or demonstrate activities rather than have students do the activities themselves.

Curriculum, Instruction & Assessment

Before SS&C began the science teaching at California High School was quite traditional. As indicated previously they used a typical layer-cake approach with 9th grade physical science and 10th grade biology. The instructional methods themselves were also quite traditional with lectures dominating instruction. In addition, instruction was focused on definitions and information rather than helping students construct understanding. Hands-on activities were relatively rare. Those hands-on activities that were used tended to be traditional verification, cookbook type labs where students were given a list of step-by-step instructions to follow. Assessments were predominately multiple-choice tests, with little if any open-ended written questioning. Overall, the 9th grade instruction at California was classic textbook-based traditional science instruction.

During the first year of SS&C implementation (1995-96 school year) the teaching appeared mixed; there were some teachers who dramatically altered their instruction in line with the tenets of SS&C, while there were others who still seemed to stick with traditional techniques. The core group of teachers made a good faith effort to use an inquiry-oriented sequence prescribed by SS&C. These teachers described themselves as

more facilitators of learning rather than purveyors of knowledge. They did many more hands-on activities than before SS&C (they said twice as many as they used to) and believed that the students were much more actively engage in science than they used to be. They even believed that the students discussed more in class because of SS&C. The students clearly discussed more in small groups, however, the teachers thought the students were even more willing to discuss in whole class discussions. The teachers also believed that the students were learning more from SS&C than they did in traditional science. They thought students retained better and learned more lab skills. The chemistry teacher claims that at the 11th grade he can see a difference between students who had SS&C and those students who did not, with SS&C students better able to conduct lab. All the teachers indicated that their labs are more open-ended than they used to be. Most of the labs provided some suggestions for students on how to do the lab, but also allowed students the opportunity to use some of their own procedures. One of the negative aspects of the SS&C curriculum is that it has made class preparations much more time consuming. All of the teachers thought they were spending at least twice as much time preparing for class compared to traditional teaching methods.

The teachers thought that the best way the SS&C course could have more impact is to improve the organization. This would also help teachers with class preparations. They have added storage cabinets with large plastic bins for each activity, and have added more equipment for the 9th grade activities. They now have a box for each SS&C activity. The box contains all the necessary equipment and special instructions for the teacher. They also maintain a filing cabinet with written copies of all activities. Each year they put suggestions and changes in this file so that next year when they pull out the activity again they can make necessary changes.

One of the most dramatic changes has occurred in the area of assessment. They have completely changed the way they assess students. They have stopped using multiple-choice tests and have gone to all essay and short answer tests. They also try to cast all tests in real-world contexts. They claim the tests now more closely match the instruction

and the skills they expect students to learn. On the other hand, their students are still subjected to a traditional, multiple-choice test administered by the state of California. The teachers are concerned about their students ability to take these multiple-choice tests, given they have so little experience with them in their science classes.

During the second and third year of SS&C California High School continued to implement SS&C, however, they have slowly begun to also implement some of their own activities. Once could describe their program as a "slow creep" from SS&C to their own activities. They still implement approximately half of the priority SS&C activities, however, the other activities were replaced for a variety of reasons. Some activities were replaced because the staff did not believe they worked very well, others because they did not have equipment to implement them, and still others to make room for a new unit on health to meet state requirements. Some of the SS&C activities have also been modified, but most of the modification has been to help the activities fit their equipment or to refine some labs that they did not think worked well. The only aspect of the curriculum that they do not use is the readings. Many of them were viewed as too difficult for their students and were dropped. They still use some of readings, but have replaced SS&C readings with some of their own articles.

Surprisingly, despite the alterations in the activities, the philosophy of SS&C still remains in tact. The activities written by the staff use an SS&C sequence, meaning that they begin with a hands-on activity and are inquiry-oriented in nature. They even use the original sequence of units provided by SS&C. Even where units have been replaced, the staff has still decided to stick with the sequence provided in the beginning of the program.

Teacher Enhancement

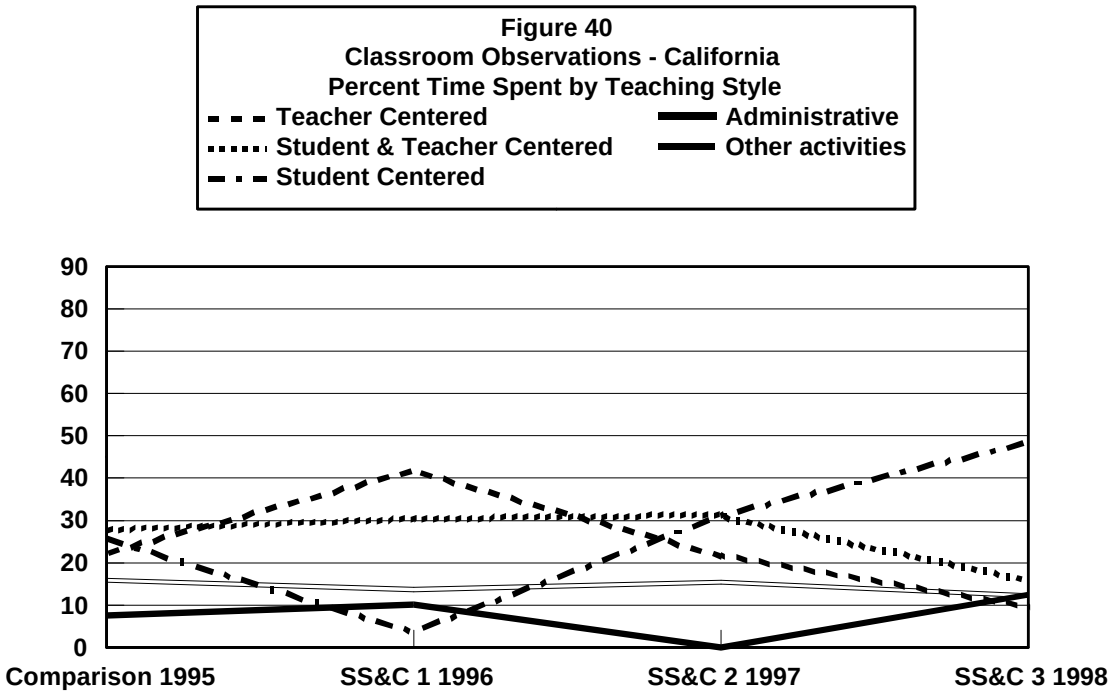
Four of the six 9th grade science teachers at California attended the two summer workshops. The two teachers that did not attend were new to the school and were not teaching at California when the two workshops were offered. The teachers thought the summer workshops were fun, and they enjoyed meeting with other teachers across the country who were also using SS&C materials, however, they did not think that the workshops had a great impact on their teaching. One of the four teachers wrote a curriculum unit as part of the workshop, but once again, he did not think it had a great impact.

The three California SS&C sites held some of their own workshop/meetings during the first and second year of SS&C implementation. They met three times during the first year to discuss SS&C issues. The California teachers said they found these regional meetings more valuable than the national meetings because it was a smaller group of teachers and because they were able to actually address issues and make modifications in activities.

Of all the "teacher enhancement" activities, the teachers at California believe that their own department meetings have made the greatest impact on their teaching. While working as a team they have struggled with the first year of SS&C and have solved many of the implementation problems themselves. The 9th grade teachers are a close group, and they seem to work together as a team very well. They seem to enjoy the long hours, and working together to solve problems. They all meet everyday over lunch and appear to truly enjoy each other's company. The process of working together to implement SS&C seems to have had the greatest impact of all enhancement activities. Two of the 9th grade teachers seem to have really hit it off and they serve as the lead teachers for SS&C. They have both been teaching at the school for more than 15 years.

Analysis

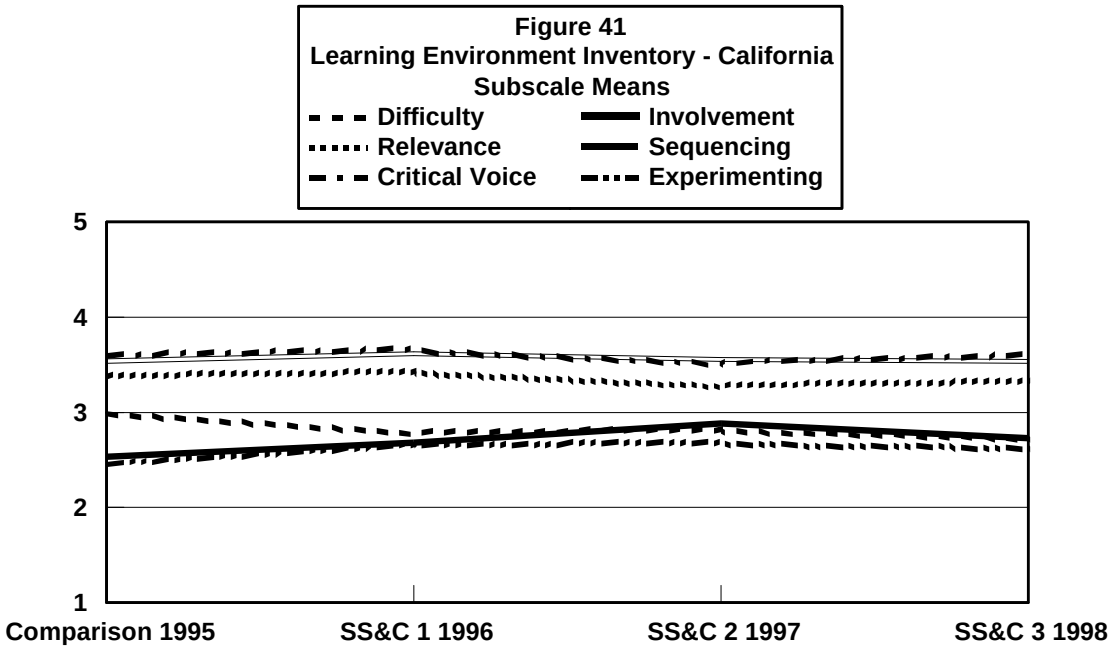
Over the four years of the SS&C project, the science department has remained relatively stable. A core group of four teachers have been involved with the project since the beginning and they continue to teach 9th grade SS&C today. The other teachers come and go over the years, but the staff at California has organized the activities and equipment into boxes, which helps new teachers implement SS&C. The common preparation period for all 9th grade teachers also helps transition new teachers into the program. At any rate, the stability and consistency of the program at California helps make it possible to attribute changes student performance to the SS&C curriculum.



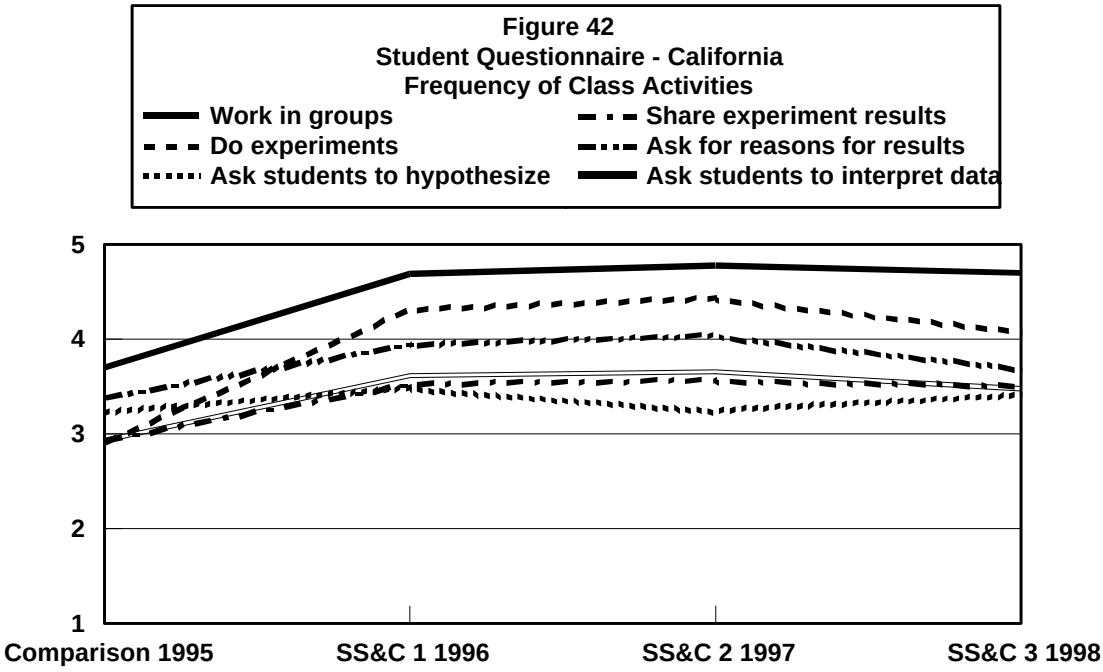
As indicated by the class observations the comparison year was almost equally mixed between teacher-centered and student-centered activities. (See Figure 40 and Table 40). Surprisingly, during the first year of SS&C implementation, the use of teacher-centered activities was observed to actually *increase*, while student-centered activities appeared to decrease. This was contrary to the tenets of SS&C. During both the fall and spring observations teachers were observed showing filmstrips and having students listen to a

lecture and complete worksheets. During the second and third year, things appear to have changed in a positive way; by the second year teaching was similar to the comparison year with an equal mix of teacher and student centered activities, and by the third year a significant increase in hands-on, student-centered teaching was observed.

These results appear to fit with the slow transition into SS&C that was observed at California High School. There were two 9th grade teachers that were very committed to SS&C, however, the rest of the staff was slow to convert. They had several relatively new teachers that had to be trained in the methods. At the same time they had several experienced teachers who stuck with their old methods and were slow to change. The organization of all materials into boxes appears to have helped all teachers' finally transition into SS&C methods. They all do the same activities at the same time, with the same equipment, which has helped to make the instruction from teacher to teacher more consistent. There are still one or two teachers who have not completely adopted SS&C methods, but the majority of teachers at California are now all using the SS&C activities and philosophy.



The student questionnaire results do support a significant change in the learning environment at California High. (See Figure 41 and Table 41). During the first year of SS&C there were significant increases on the LEI on both the sequence and experimenting scales. These changes suggest teachers used a more inquiry-oriented sequence and more opened-experimenting during SS&C. The increases in sequence and experimenting appeared to hold steady or slightly increase during the second and third year.



On individual questions about class activities the students indicated that from the comparison year to the first year of SS&C there was an increase in the frequency of doing experiments, sharing the results of experiments, hypothesizing, giving reasons for the results of experiments, interpreting data, and working in groups. (See Figure 42 and Table 42). Likewise, the students at California reported a decrease in reading the science textbook and watching videos. (See Figure 43 & 44 and Table 43 & 44). These changes appeared to hold steady during the second and third year. All of these changes support the notion that the environment included more student-centered, inquiry-oriented approaches as recommended by SS&C.

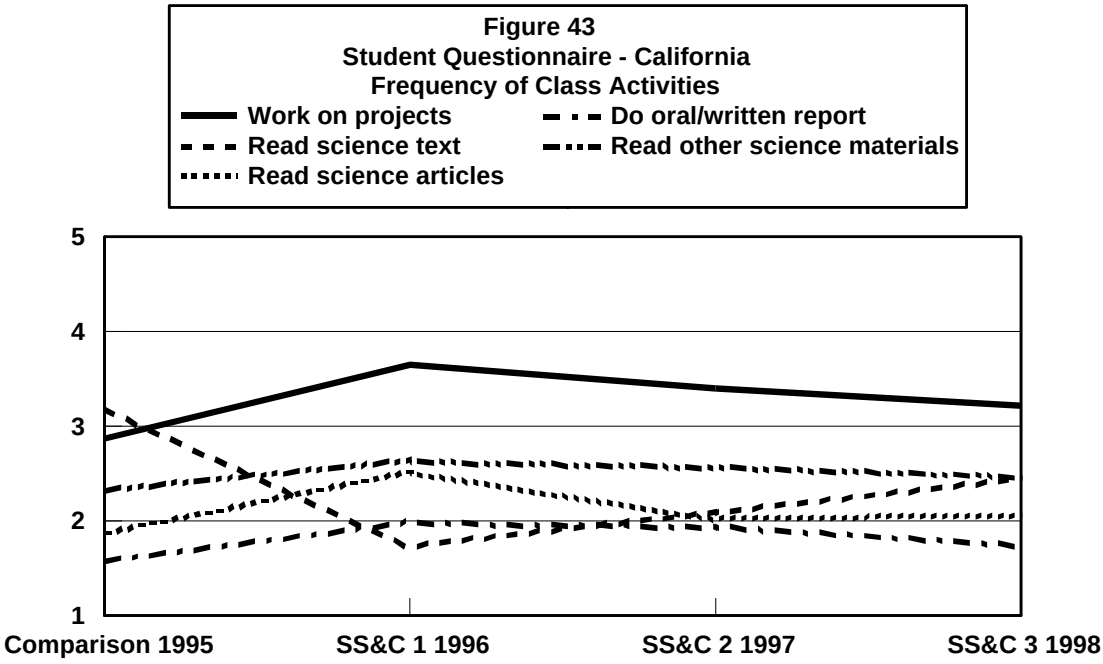


Figure 43
Student Questionnaire - California
Frequency of Class Activities
Work on projects
Do oral/written report
Read science text
Read other science materials
Read science articles
5
4
3
2
1
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998

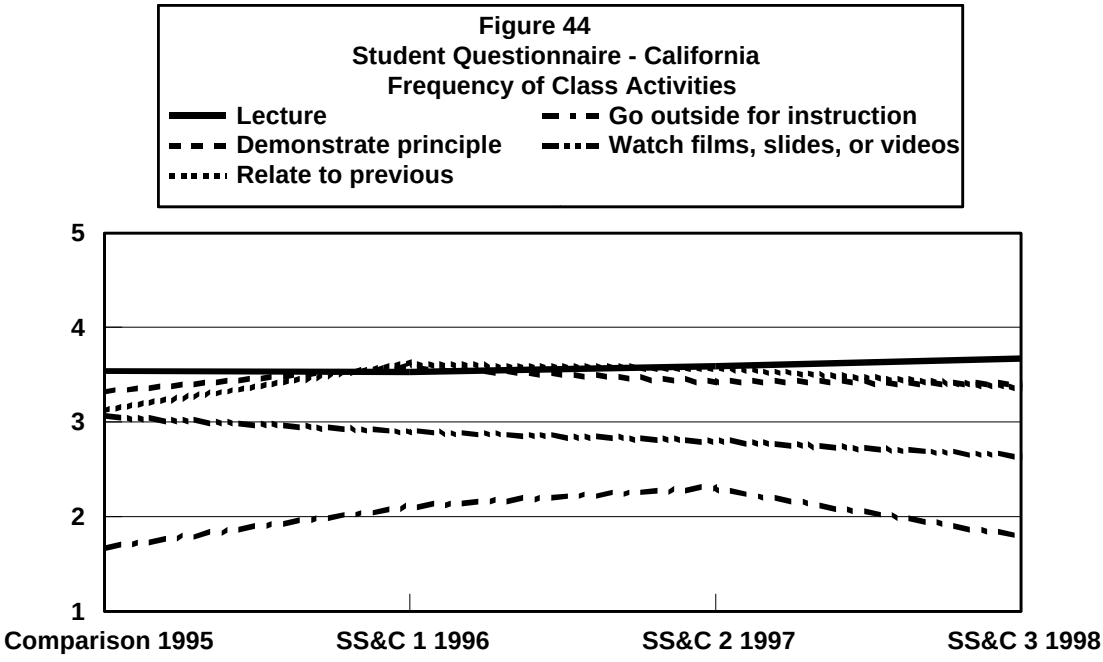
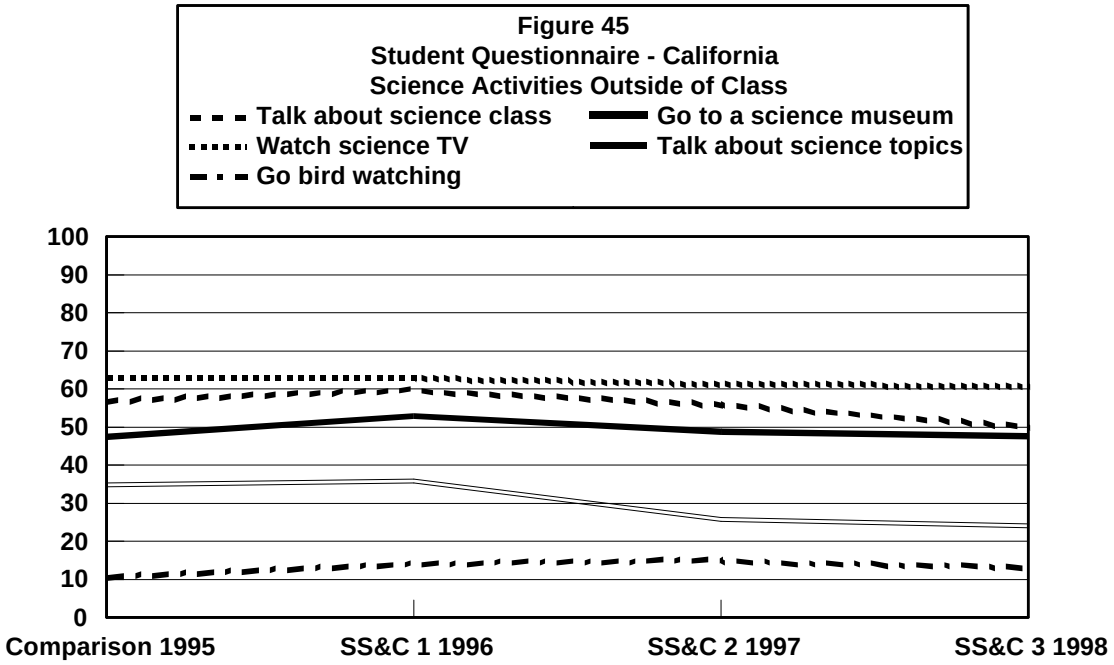
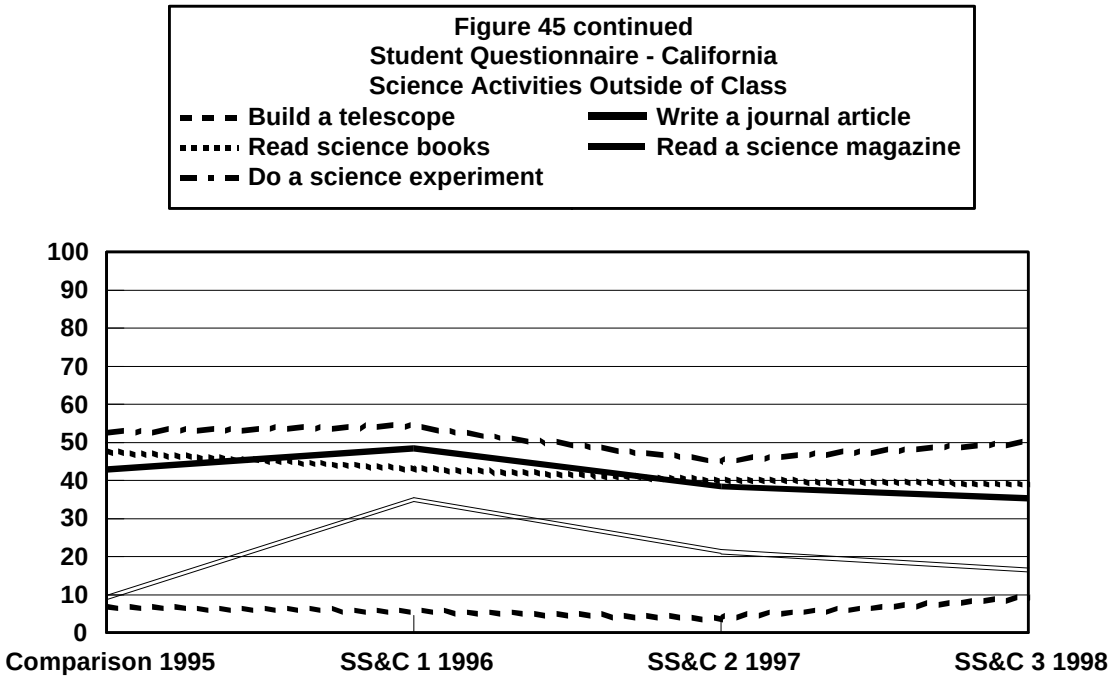


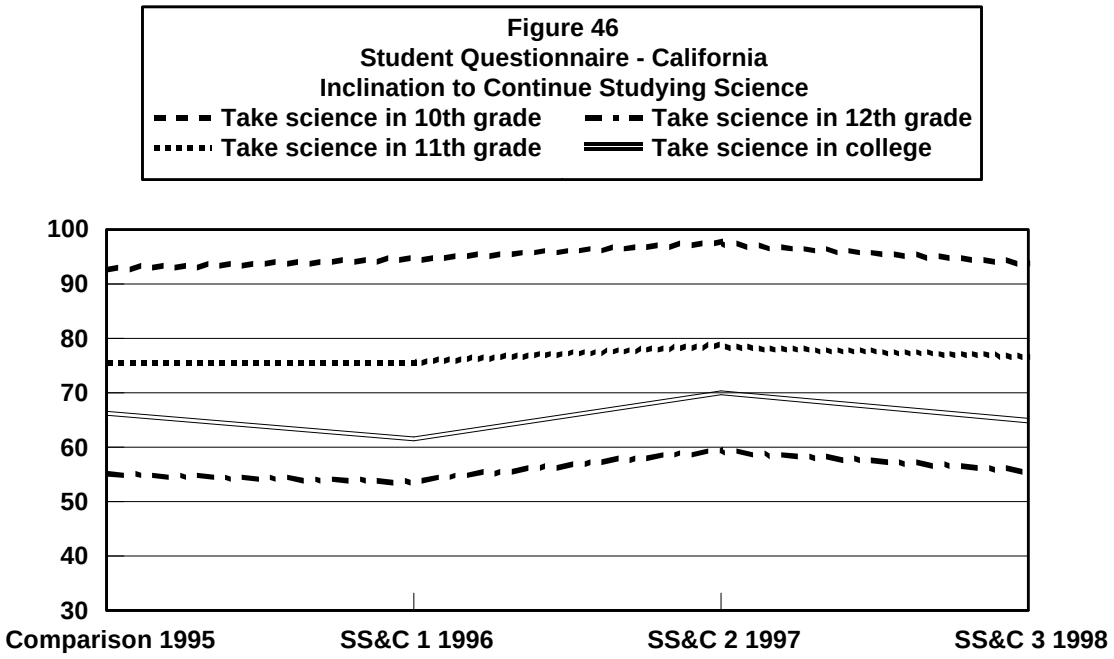
Figure 44
Student Questionnaire - California
Frequency of Class Activities
Lecture
Go outside for instruction
Demonstrate principle
Watch films, slides, or videos
Relate to previous
5
4
3
2
1
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998



The students also reported on the frequency of science activities they did outside of class. There were no significant changes noted in the first year or subsequent years of SS&C, except on going to a science museum and writing a science article, both of which increased during the second and third year of SS&C. A decrease was found on reading books about science. (See Figure 45 and Table 45).

Figure 45 continued
Student Questionnaire - California
Science Activities Outside of Class





The inclination to study science in the future remained fairly constant. During the second year of SS&C there was a slight increase in students' inclination to study science in 10th grade and students' intent to pursue a career in science, but by the third year of SS&C both measures leveled off. (See Figure 46 & 47 and Table 46 & 47). Students' attitudes toward science were also quite constant, except for a slight decrease in students' views that science is fun. (See Figure 48 and Table 48).

Figure 47
Student Questionnaire - California
Science Motivation

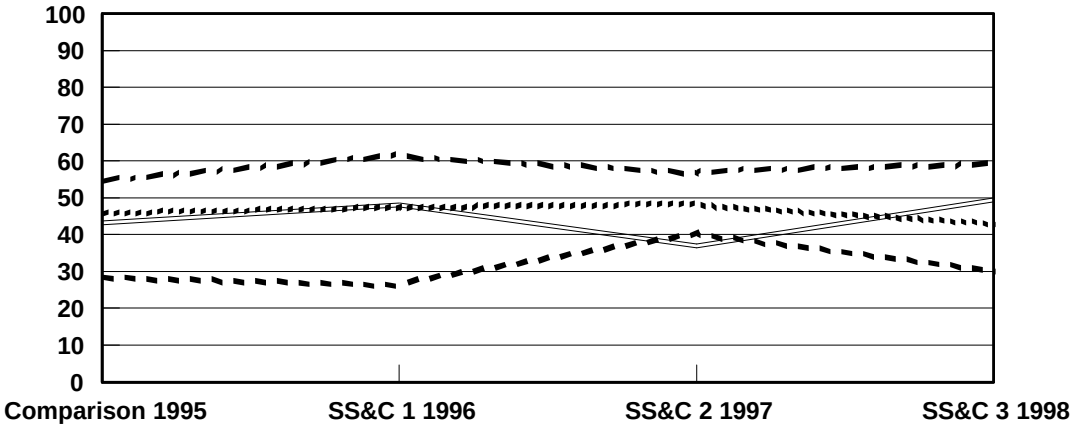
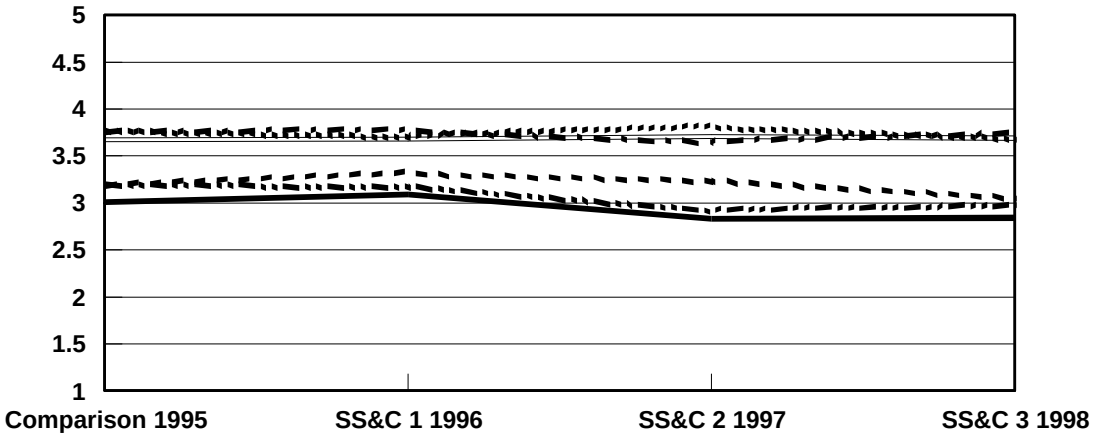
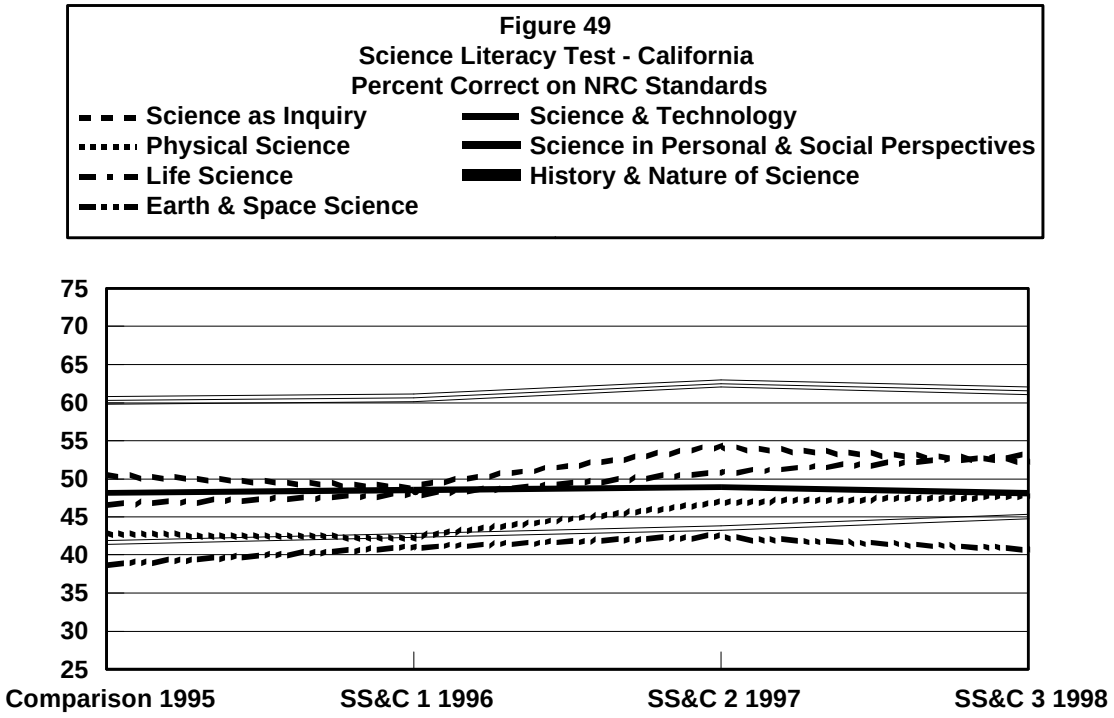
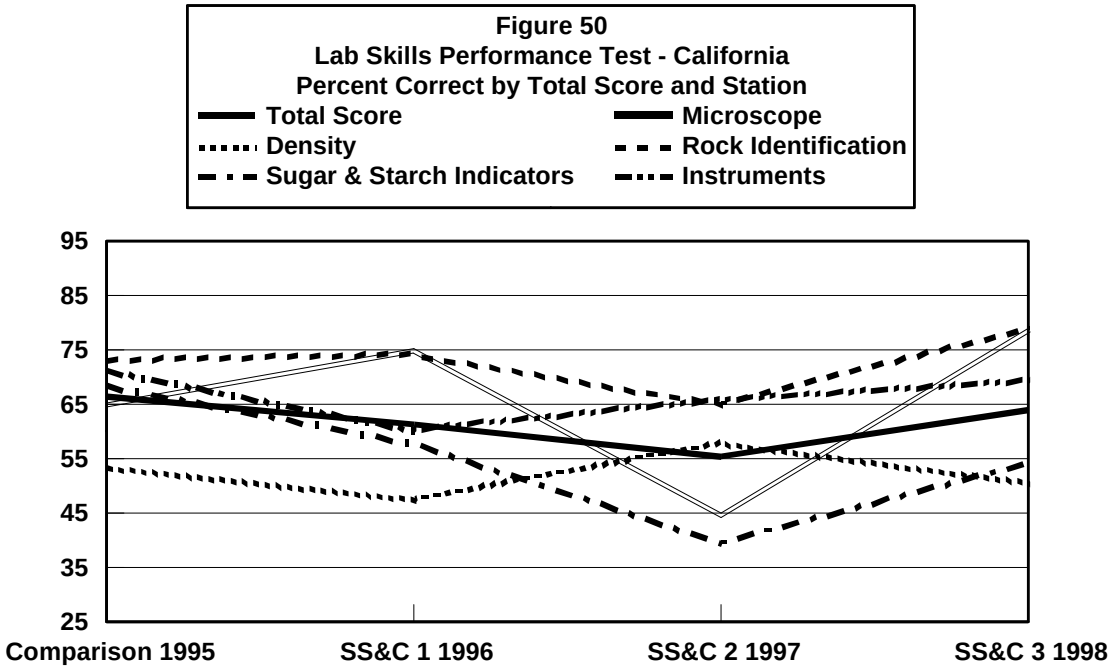


Figure 48
Student Questionnaire - California
Attitudes Toward Science





During the second and third year of SS&C, increases in achievement were found on the multiple-choice test linked to the science standards. Students' at Sacramento High School scored significantly higher than comparison students did on questions about science as inquiry, physical science, life science, and earth science. (See Figure 49 and Table 49).



Despite the increased found on the multiple-choice test, decreases were found on the hands-on lab skills test. SS&C students had lower scores than the comparison students during the second year, but by the third year of SS&C scores returned to comparison year levels. The largest decreases in the second year were found on the chemistry indicators station and the microscope station. (See Figure 50 and Table 50).

During the second year significant increases were observed on the hands-on full investigation test, however, during the third year scores declined back down to initial levels. (See Figure 51 and Table 51). Scores on the written full investigation were significantly lower during each of the SS&C years. (See Figure 52 and Table 52).

Figure 51
Hands On Full Investigation - California
Total Score and Subscale

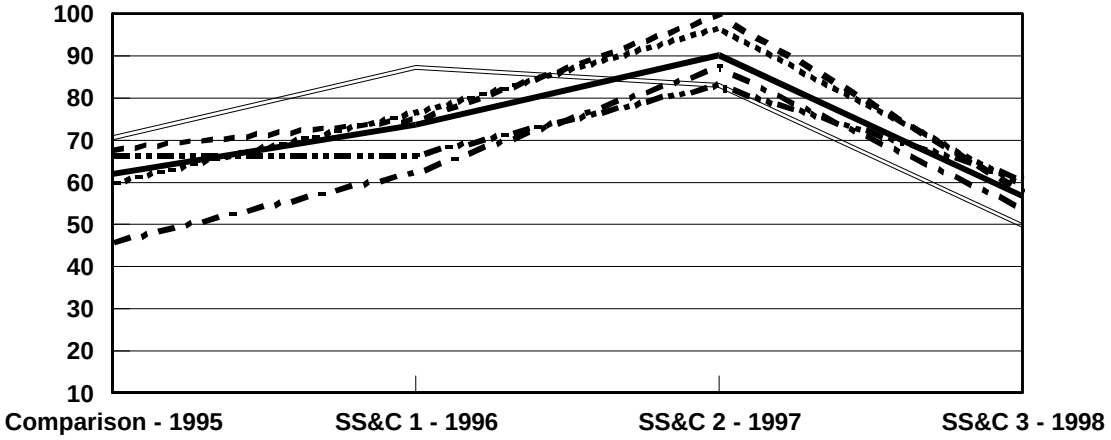
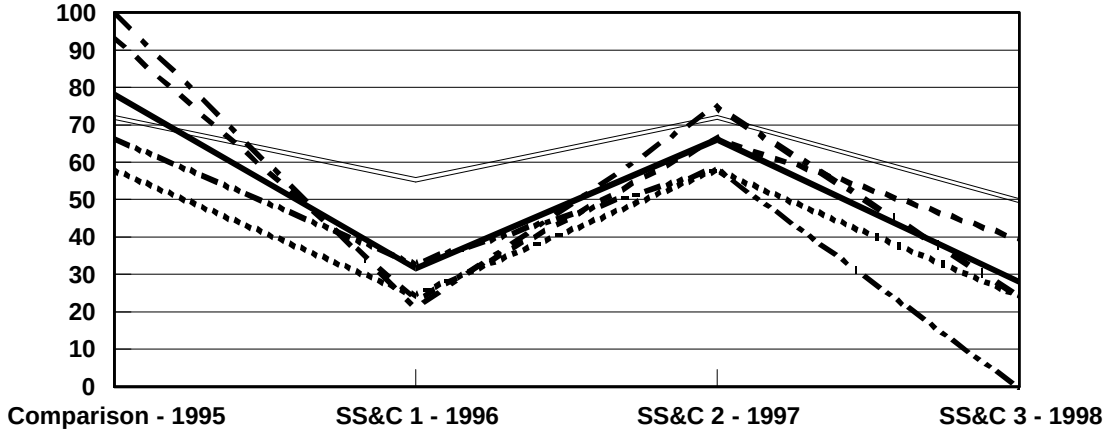


Figure 52
Written Full Investigation - California
Total Score and Subscores



Concluding Remarks

Overall, the results at California High School suggest that the science department has fairly dramatically changed the learning environment in accordance with the NRC science standards. It took several years for the changes to become institutionalized among the 9th grade teachers, but once they did so the changes appear to have stabilized. Several teachers indicated in interviews that even if they moved to a different school they would not change their SS&C philosophy and approach to teaching. The changes in the learning environment appeared to significantly affect students' achievement on the multiple choice test of science literacy, but there were some decreases in students' research design and investigation skills, suggesting that the hands-on environment has not had a positively affect on all aspects of students' achievement.

The transition to SS&C at California High School was one of the slower transitions observed in this evaluation. While on average the teaching was quite inquiry-based and hands-on, there was wide variability in the implementation. Several teachers at California High School were resistant to the new methods and slow to convert. At the same time, the science department faced some turnover in staff and was constantly training in new teachers. The variability in teaching may help explain the somewhat inconsistent achievement results; with increases in some areas, but decreases in others.

The Texas High School Experience

School Setting

The stated mission of Texas High School is to offer its students an educational program that will provide a foundation for becoming good, productive citizens. The vision is for Texas high school to be an institution that offers leadership and academic training for students, facilitates the learning process, addresses the socialization needs of students and prepares students to enter adulthood in an era of rapid business and technological change.

The 9-12 high school is near downtown and only blocks away from two Universities. The surrounding urban area is small tract housing or larger three story walk-ups. The residential area is somewhat mixed with larger single family homes further away from the school. The community ranges economically from very low to middle class. The student population is almost entirely African American with a few Asian and Hispanic/Latino students. The community and the population of the school have been stable over the course of the study.

The school is housed in an older traditional style three story brick /cement block building in a "U" shape. The building is generally clean but minimalist and stark in appearance. The parking lot is fenced in and the classrooms are kept locked. Staff are assigned to watch the halls but the spirit is more one of concerned parents keeping track of their children than policing. The science classrooms are grouped together in one hall. Most science teachers have two classrooms in the hall, a traditional classroom with moveable desks and a science laboratory room. The teacher decides which days the students will be in which rooms. The traditional classrooms are small with blackboards, some storage space and often an overhead projector or a computer. Occasionally students' work or bulletin boards are in view. The laboratories have tables or laboratory stations with traditional science equipment such as water and gas. The laboratories are under-equipped and much of the equipment that is available is old. Sometimes the teachers have to purchase their own supplies and materials.

Science Program

Although the science program has been evolving over the years we have been collecting data, there has been a continuous emphasis on reading, writing and mathematics skills. This emphasis is due to the Texas Assessment of Academic Skills test (TAAS) that all of the students must take and pass prior to graduation. There have been approximately 11 science teachers in the school each of the data collection years. For example, in 97-98 there were 50 different sections of science, twenty of which were SS&C, offered for approximately 1000 students. The teachers usually teach in their areas of specialty so of the 11 science teachers, five to seven would be teaching from 2 to 6 sections of ninth grade science. There were only two teachers who taught ninth grade science every year. Other slots have seen a lot of turnover with these teachers staying for one or two years and then leaving or moving into different grade levels. The science classes were ability grouped with regular, honors, ESL and transitional (usually above grade level aged children) classes. Ninth grade science class sizes over the years ranged from 15-34. Classes are offered on a 90 minute block schedule with different classes on alternating "A" and "B" days.

SS&C for 9th grade students was implemented in 1995-96 with the grade 10 options remaining the same as the previous year. In 1996-97 and 97-98 SS&C was offered for both 9th and 10th graders. In 95-96, 96-97 and 97-98 all grade 9 students were required to take SS&C at some level and most grade 10 students did so as well in the 96-97 and 97-98 years. Some grade 10 students took biology or honors biology instead of SS&C those years but only a few sections were offered. The SS&C teachers had a classroom set of biology and physical science textbooks for the students to use as references.

Through the summer of 1998, students could take biology, biology II, environmental science, chemistry or physics after the two years of SS&C. There were no AP classes available. One semester long meteorology and marine science classes were also offered but they only counted as elective sciences not as one of the three full years of laboratory science that were required by the State.

In the summer of 1998, the State of TX adopted two, new, year long, science requirements for all students: integrated science and biology. The high school also decided to offer AP courses. Therefore in 1998-99 the course sequences will be grade 9 integrated science (SS&C style), grade 10 biology (pre AP or regular), grade 11 pre AP chemistry, chemistry, AP biology, or environmental science; and grade 12 pre AP chemistry, chemistry, pre AP physics, AP biology, or environmental science.

School Climate

Based on the interviews, the principal appears to be astute politically and concerned about enhancing the reputation of the school. He says he is personally interested in school/parent involvement and concentrates effort in that area. He was aware of and able to articulate the goals in the NRC science standards. The district is quite large and the principal felt that he was responsible for implementing many of the District's and the State's constraints on instruction and curriculum. Over the years the principal's interest in SS&C has changed. He was quite supportive in the first years when the project was funded and had a national focus, but that has dwindled to what appears to be a neutral attitude since the funding was cut.

Hope for and belief in the students is high among the teachers. Some of the science teachers are former Texas High School graduates who have come back to share their success and understanding with the students. The students are generally polite and are well behaved when kept occupied. There is an acceptance of school and the attendance rate is 92%. The students are mixed academically and special classes are available. There are fewer opportunities for students at the high end although this may be changing with the introduction of AP classes in the 1999-2000 school year. As is often the case, the student body seems to favor athletics and activities outside of school over scholastics. The attitudes of the students and teachers have stayed much the same over the years.

Science Department Climate

Over the years of data collection the leadership in the department has undergone some change. The SS&C liaison was the former science department chair. She was department chair for many years prior to, and for the first two years of, the SS&C adoption but gave up that position in 1996-97 school year and then retired at the end of 1997-98 school year. The new department chair has coordinators for the different grade levels but all issues including curriculum and equipment are coordinated between the chair and the individual teachers. The new chair was convinced of the value of SS&C and attended the summer 1996 SS&C workshop in Texas. He generally teaches upper division science classes and commented that the students who had taken SS&C were better prepared than those who hadn't. He does not teach SS&C.

Several teachers in this city had been involved in the SS&C project before the first implementation workshop in the summer of 1995-6. At this school five teachers, including the school's SS&C liaison and science department chair, had been working with the SS&C project before the summer teacher enhancement effort of 1995 and two of them had provided the project with sample curricular material. The SS&C project was supported by the School District and a local university provided ongoing staff development for the first two years of the project. More details about the enhancement efforts is included in the Teacher Enhancement section.

In the first year of SS&C implementation at the grade nine level, there were five teachers teaching SS&C. Of these five teachers four had attended the training in the summer in MT and the others had the opportunity to attend the city-based training. The teachers also had their planning periods structured at the same time so that they could work together on SS&C classes during the school year. The five teachers were generally experienced teachers who were teaching SS&C as a new curriculum. The teachers were committed to following the curricular materials and to providing hands on experiences.

In the 1996-7 year the summer workshop for training SS&C grade 10 teachers nationally was held at Texas High School. Many local teachers including the entire Texas High School science faculty, also attended the general sessions. Although the teachers this year had their planning periods coordinated so they could work on SS&C, there was no ongoing external professional development because the grant had not been renewed. There were about 34 sections of SS&C offered, however since it was essentially required for all grade 9 and 10 students. There were five teachers for grade 9 and four teachers for grade 10 with some teachers teaching mixed preparations. The teachers were a mix of experienced and new teachers. The SS&C coordinator, although no longer department chair was available to answer questions about SS&C and to encourage the implementation effort. The teachers tried to follow the curricular materials but at the grade 9 level they were making changes based on their previous year's experience. The 9th grade teachers had different strengths with one first year teacher and four experienced ones. All of the teachers used the SS&C curricular materials. The more experienced teachers are somewhat set in their ways and implement SS&C with a decidedly individual bias. Although all of the teachers are certified to teach science, there were differences in ease with which they covered the diverse topics required by the SS&C curriculum.

The 1997-98 year was much the same as the previous year. There were five teachers teaching grade 9 SS&C and they had a mix of skills. Three of the five teachers were career teachers and have been teaching SS&C since the program began. The other two teachers were new, a first year teacher and a second year teacher. The newer teachers do not have prior preferences or set individual styles, but neither do they have the skills that come with experience. The new teachers have had to make modifications in SS&C to ensure good classroom management. Only one of the experienced teachers seems to have internalized the SS&C instructional philosophy to any extent. The two new teachers have internalized some of the philosophy (or learned it in their science teaching preparation programs) but have not taken the step to allowing students to be responsible for their own learning.

Curriculum, Instruction and Assessment

Throughout the data collection period there has been a pervasive feeling that the students are under prepared. For example, although the teachers felt that concepts covered in grade 9 SS&C were appropriate, they felt that their students wouldn't be able to understand the concepts using the procedures outlined in SS&C. The teachers did not feel that the ninth graders were ready for the independence SS&C required nor did they think the students would be able to extrapolate the necessary conceptual understanding from the laboratory activities. The teachers felt that they needed to provide more direction and theory; that the students needed more guiding through the curriculum. There was also some concern about freedom in laboratory as it related to the possible misuse of equipment such as slides, microscopes, razor blades, scissors, etc. perhaps because of lack of experience with the proper procedures and demeanor in middle school. So the teachers were reluctant to let the students have too much "free rein" in experimentation. This led to much more teacher direction in the classes. The imposition of teacher direction increased over the years. This may be because of the lack of ongoing professional development or because of the inexperience of the teachers.

The teaching in the 1994-95 year was very traditional and has continued to have that flavor even with the changes forced by SS&C with its constant activity and no textbook. The most significant changes in teaching toward hands-on and inquiry showed up in the 1995-6 year when the teachers were very committed to the philosophy of S&C and most had attended the national professional development. This was diluted by the 1996-7 and 97-98 years.

Across all of the years students were not encouraged to experiment much with new ways of doing things or thinking. Most of the teachers believed the students needed to guided; that the teacher needed to tell the students what to know. The general approach to classes was to help the students prepare for college. The view among the teachers that higher education would provide a way to better the students' lives probably contributed to this

emphasis. There was a sense of "wasn't that cool" about the hands on activities but then a clear need to copy down the correct answer rather than exploring the concept.

When asked in the 97-98 year about how the SS&C had affected them, the six teachers interviewed had somewhat mixed responses. Some of this was due to the large gap in experience of the teachers. Some had been at the school for a very long time and some were first and second year teachers. The teachers liked the hands on nature of SS&C but thought it was very time consuming and unstructured. Some felt that they did not have adequate resources to teach the class. They all felt that student levels of participation and discussion had increased but only half felt that this contributed to greater student understanding and only two felt this changed teacher/student interactions. All but one felt that they had changed their teaching and that one said that he had always been a hands on teacher. Despite this acknowledged change, however, only two of the teachers felt their philosophy toward science education or their perception of how students learn had changed. Two of the teachers said they had not changed their assessments but others mentioned testing less, doing more short quizzes and using open book tests. They were mostly neutral about the SS&C experience. They felt it might have been more effective if it were more structured and better presented.

Teacher Enhancement

Several teachers at the school had the opportunity to participate in the training supported by the original grant project. One of the project coPIs, Dr. Linda Crow, worked at a local University and had been previously working with the Texas School District on the middle school SS&C program. Therefore in addition to being able to attend the summer workshops with teacher from all 13 sites, the teachers in Texas were given the opportunity to participate in educational sessions throughout the first two years (1994-6) of the project. These special Saturday sessions were sponsored jointly by the Texas School District and Dr. Crow. Some funding to help purchase equipment and supplies to support the SS&C program was also provided. Five of the teachers at the high school participated in both of the summer institutes and the special Saturday training sessions.

These five also wrote some of the curricular materials the first year. Two of these teachers presently teach grade 9 SS&C. The third teacher who participated in all of the available training was the SS&C site liaison but since has retired. Another teacher, who does presently teach SS&C, participated in the second summer training session.

There has been no special training in SS&C at the high school other than the distribution of the materials. Therefore teachers new to the system do not receive training. The school has a mentoring program for new teachers, however, and new teachers learn about SS&C through these relationships. In previous years the SS&C teachers had their free periods scheduled at the same time so that they could have joint planning sessions. This was not the case in the 97-98 year and so any joint planning had to be done after school or during lunch. In the summer of 1997 there was a workshop for SS&C teachers. Three of the Texas High School staff attended. One who is no longer on the staff and two others. They brought back information and materials including the SS&C curriculum on CD.

Analysis

Thee climate and science department has remained quite stable and as a result one can attribute changes to the SS&C curriculum. The project at Texas High School began in a very positive vein. The teachers had been previously involved in curriculum development with Bill Aldridge (SS&C project director), a local University professor, and the curricular specialist for the Texas district was behind the project.

The second national workshop was held at Texas High School. The principal and staff were very involved in the workshop. The Texas principal was very much in evidence at the summer meeting and expressed his confidence in the program.

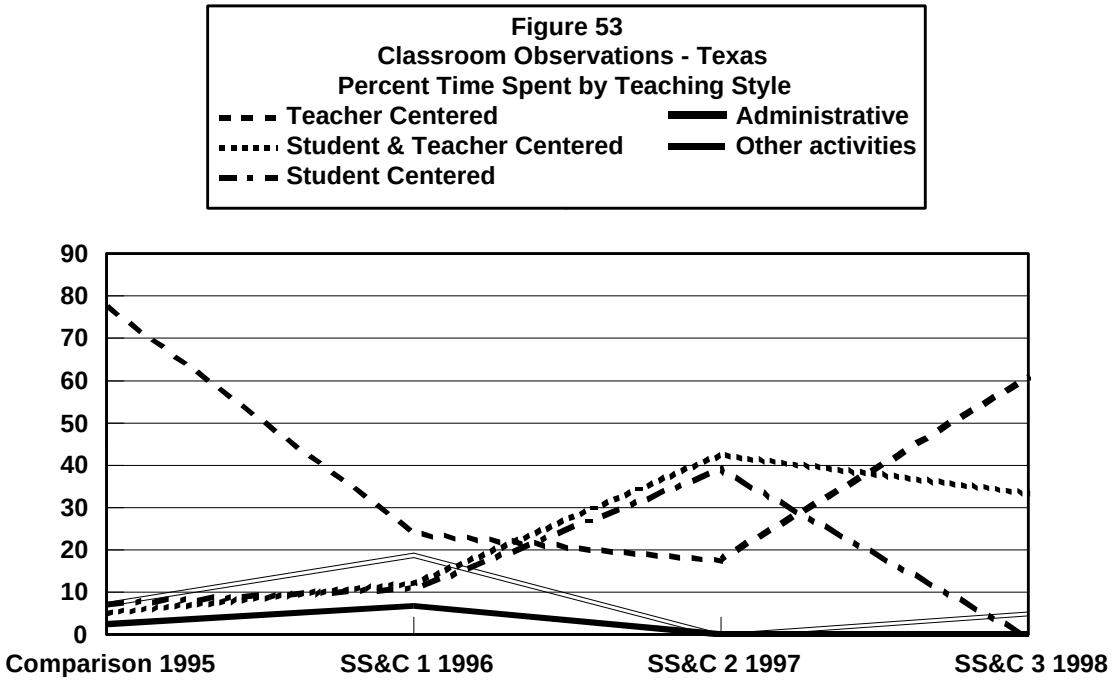
Even after the project received news of its cancellation, Texas High School was committed to continuing. This seemed mostly because of the enthusiasm of the Department Chair and SS&C liaison who had worked closely with the SS&C directors.

A separate action research study had been conducted by the teachers at Texas High School that showed very positive results for SS&C. Other teachers at Texas High School that had been trained believed in the philosophies espoused by the project. There was also a halo effect from the workshop being held at their school.

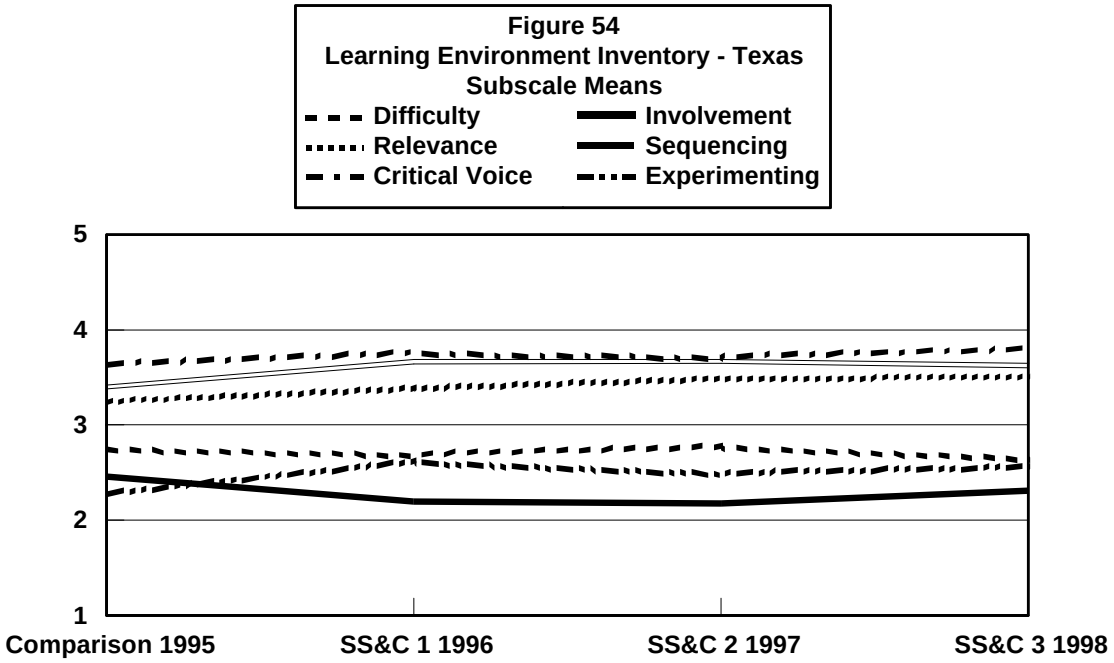
The 97-98 year showed regression away form the high levels of commitment of the 96-97 year. The liaison teacher had announced her plans to retire. Part of her decision was based on the relationship she was having with the principal over his lack of support for the science program. Principal lack of support was evidenced by his changed attitude toward meeting with the researchers as well. The first year he had been very anxious to meet with us. The second year he hosted the training but after the news of the discontinued funding he was less open to discussion and in 1997-8 he was unavailable.

The SS&C curriculum required a lot of preparation and laboratory time. This was more difficult for the teachers in terms of prep time and also required that the teachers be able to teach in an inquiry fashion. It is difficult for a beginning teacher to teach in inquiry modes. First, most of the teachers' recent science classes had been talk and chalk so they were used to that style. Also inquiry teaching requires very effective discipline which is often not easy for new teachers. At Texas High School there were several new teachers teaching SS&C—some truly new and some new to the idea of inquiry teaching. The labs are also under stocked and so to do SS&C effectively many teachers had to buy their own supplies. This may have led to a less complete implementation of the curriculum. By 1997-98 the teachers did not use inquiry hands on learning as much as they did the prior years. Also since their prep times were not synchronized as they had been the prior years, there was no time for joint planning and support of each other. The removal of the national agenda also affected the teachers. There were no national goals or outcomes they had to meet. The new chair was concerned about how the children did on the TAAS, since that was how success of the school and ultimately the department was measured. So the classes had less student centered activity and more teacher centered activity. Also toward the end of the 1997-98 year the teachers were hearing about new

requirements for science. It is possible they were less committed to a program that was likely to be wiped out.



The observations show a significant decrease in teacher centered behavior from 80% of class time the first and second years of SS&C but a return to almost original levels by the third year. The decrease in teacher centered behavior was accompanied by increases in student and student and teacher centered behavior to highs of about 40% of class time by the second year and large drops in the third year of SS&C. The first year also showed an increase in administrative activity which may have been due to the newness of the curriculum.



As indicated by the LEI scales there was little change in the student perception of their classrooms' psychosocial environments other than the increase in experimentation the first year. (See Figure 54 and Table 54). The student questionnaire items corroborate this increase in experimentation along with statistically significant increases in working in groups, sharing experimental results, asking for reasons for results, hypothesizing and asking students to interpret data. These remained significantly higher for the next year and then decreased, however, all but doing experiments remained significantly higher than the comparison year. (See Figure 55 and Table 55).

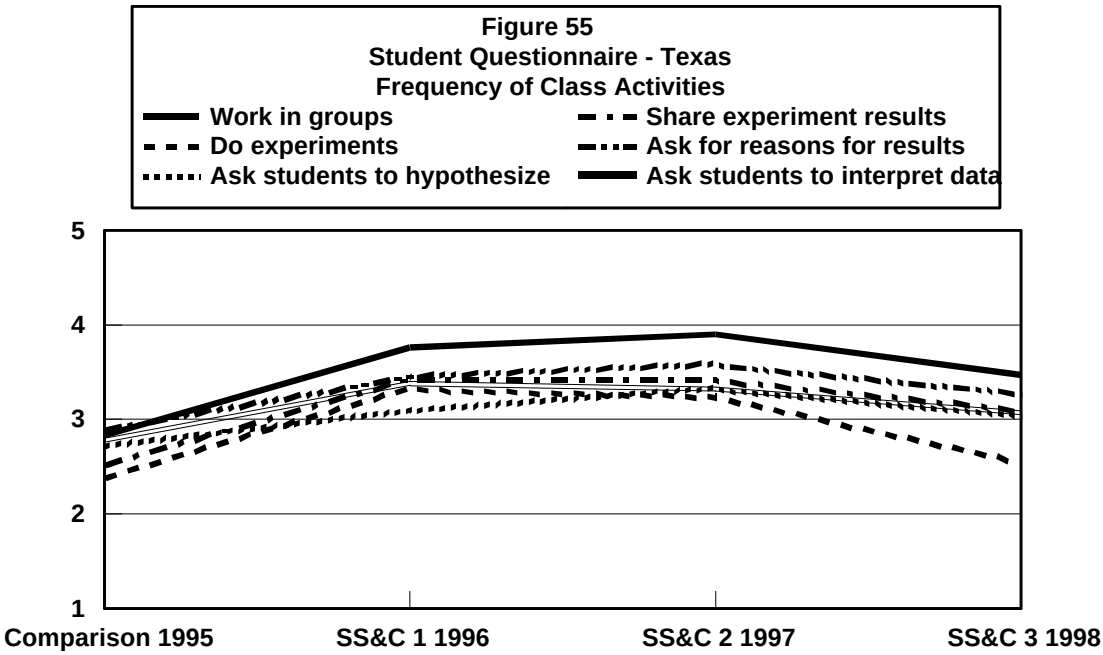
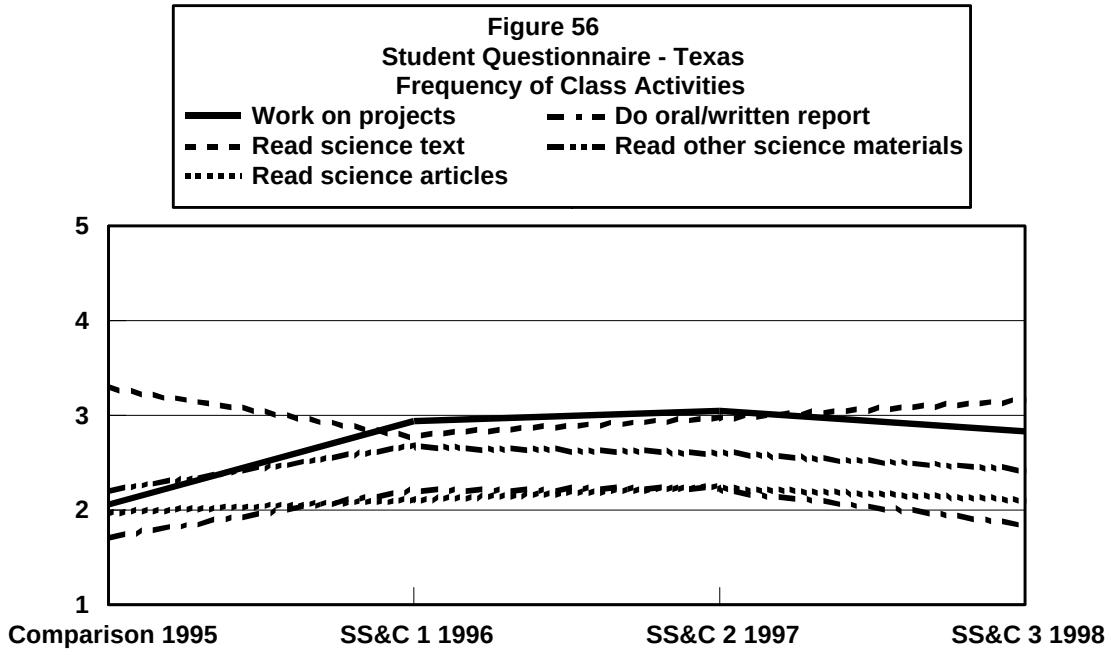


Figure 55
Student Questionnaire - Texas
Frequency of Class Activities
Work in groups
Share experiment results
Do experiments
Ask for reasons for results
Ask students to hypothesize
Ask students to interpret data
5
4
3
2
1
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998



Work on projects and doing oral and written reports followed much the same pattern except that working on oral and written reports was not significantly different from the comparison year by 1998. (See Figure 56 and Table 56). Levels of reading remained fairly constant but what was read changed from the science text to science articles or other materials and then back. These changes were significant for the first two years. No other changes in other types of classroom activities were significant.

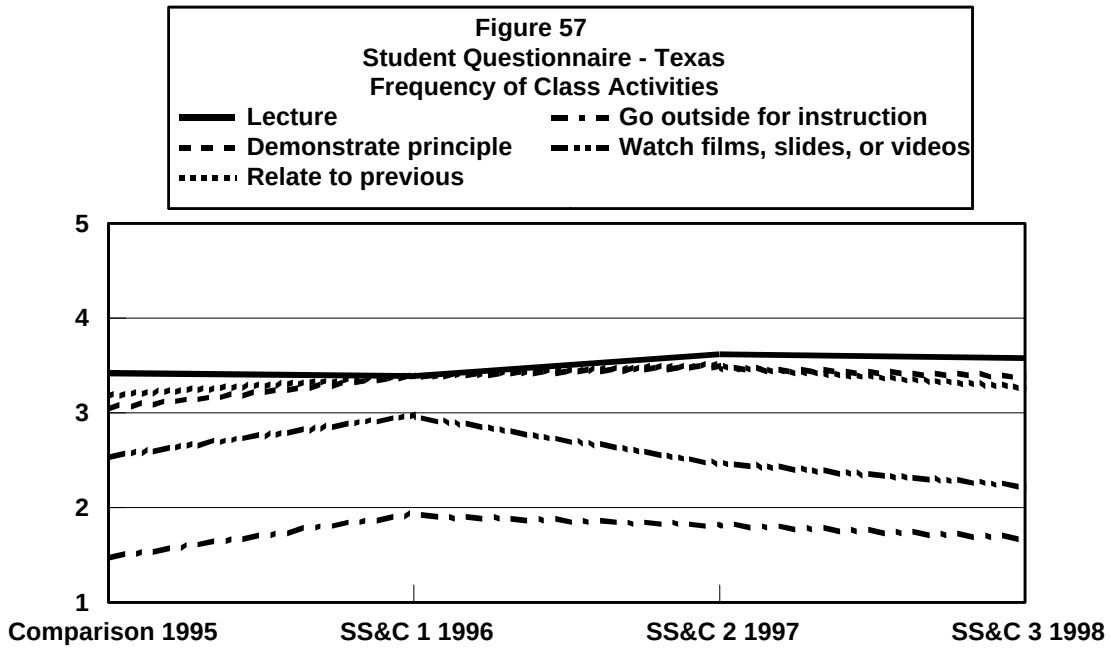
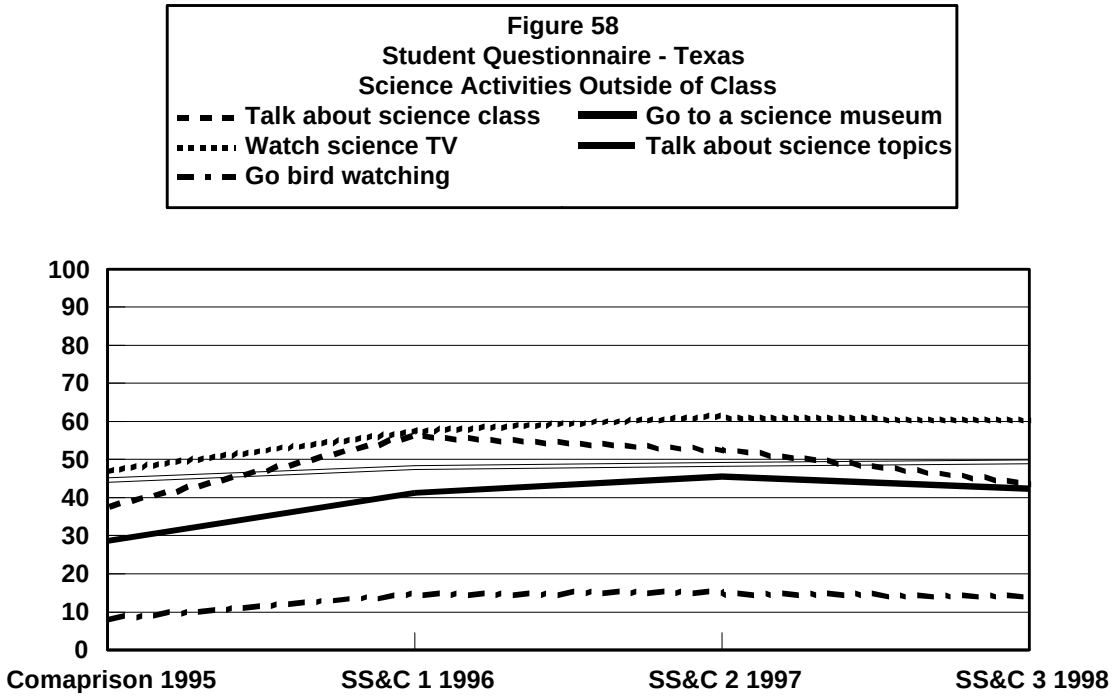
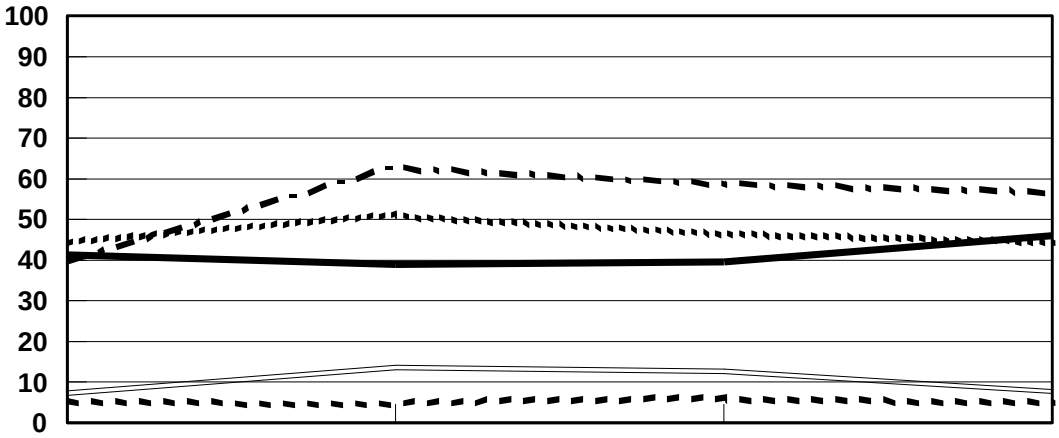


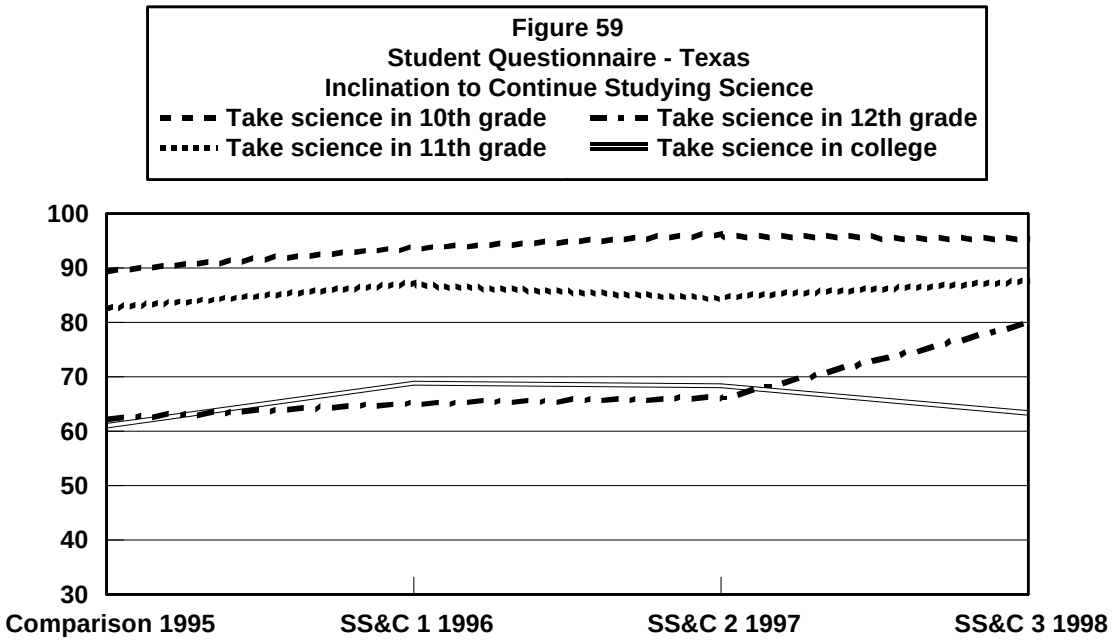
Figure 57
Student Questionnaire - Texas
Frequency of Class Activities
Lecture
Go outside for instruction
Demonstrate principle
Watch films, slides, or videos
Relate to previous
5
4
3
2
1
Comparison 1995
SS&C 1 1996
SS&C 2 1997
SS&C 3 1998



Students appeared to increase their involvement in science activities outside of class the first year and remain at these higher levels. (See Figure 58 and Table 58). The significant increases in talking about science remained significantly higher than the comparison year for all three years, as did doing science experiments.

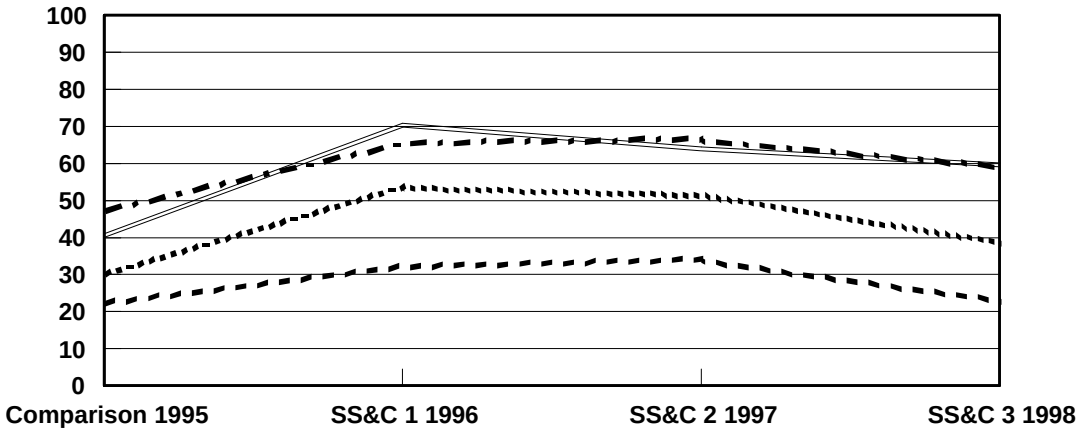
Figure 58 continued
Student Questionnaire - Texas
Science Activities Outside of Class

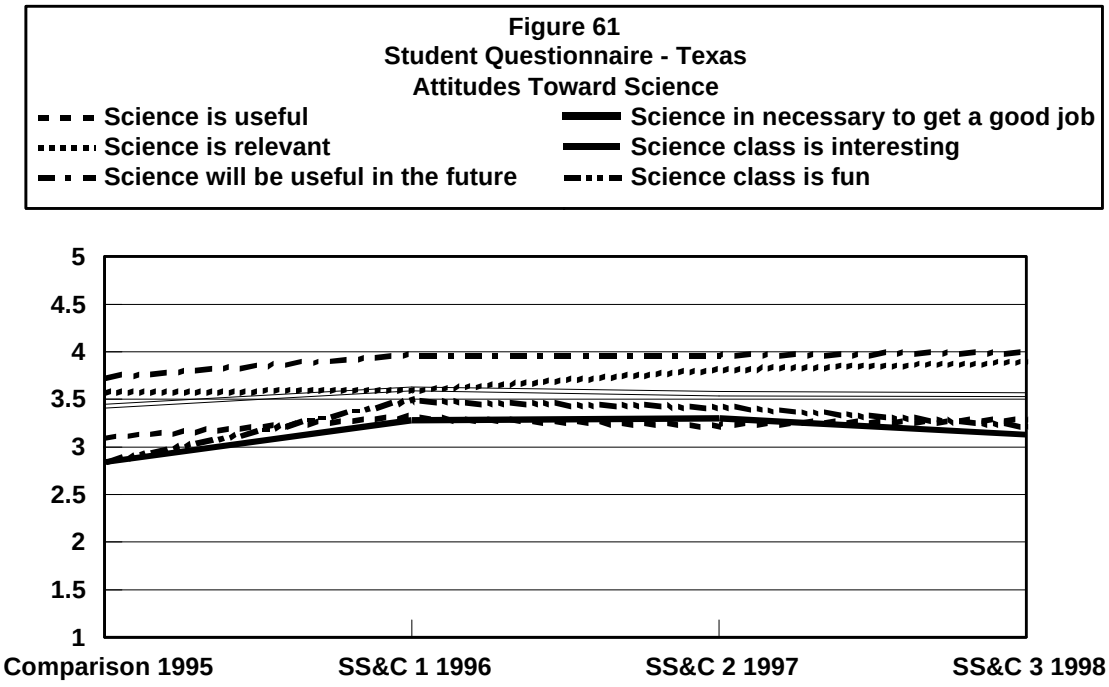




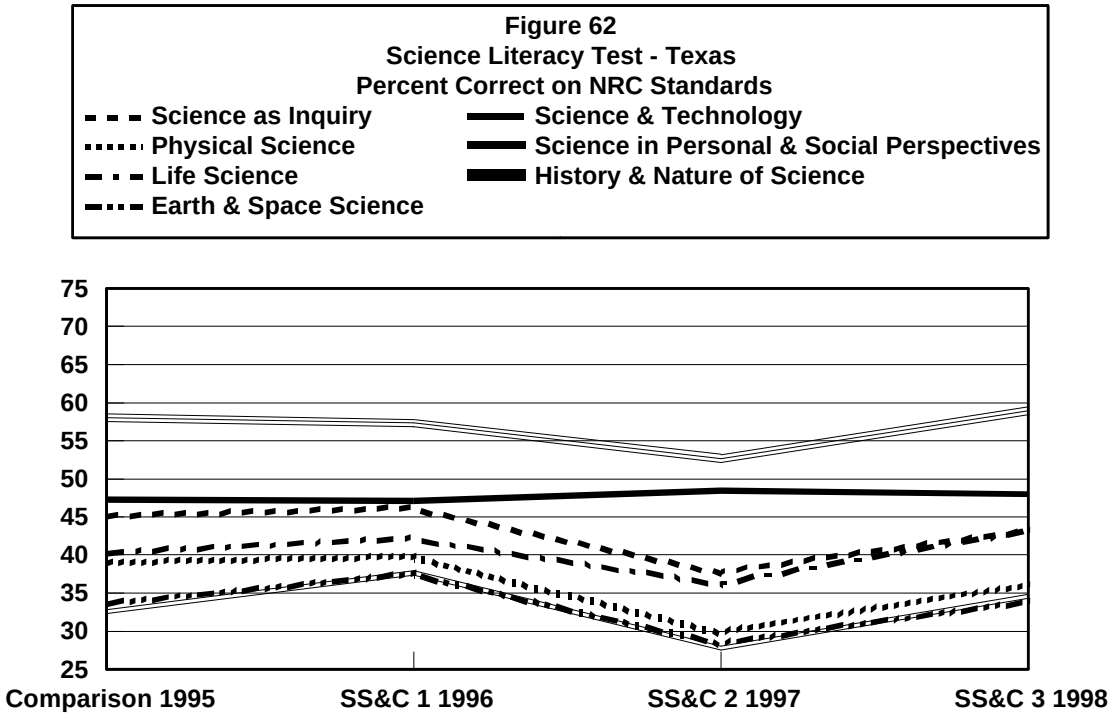
The students show the expected increase in planning to take science in grades 11 or 12 in the second and third years because of the changing State graduation requirements. (See Figure 59 and Table 59). Planning to take science in college goes up slightly but then declines to the original level. Planning a career in science and having activities that make you want to take more science go up significantly the first two years and then drop to the comparison year level. (See Figure 60 and Table 60).

Figure 60
Student Questionnaire - Texas
Science Motivation

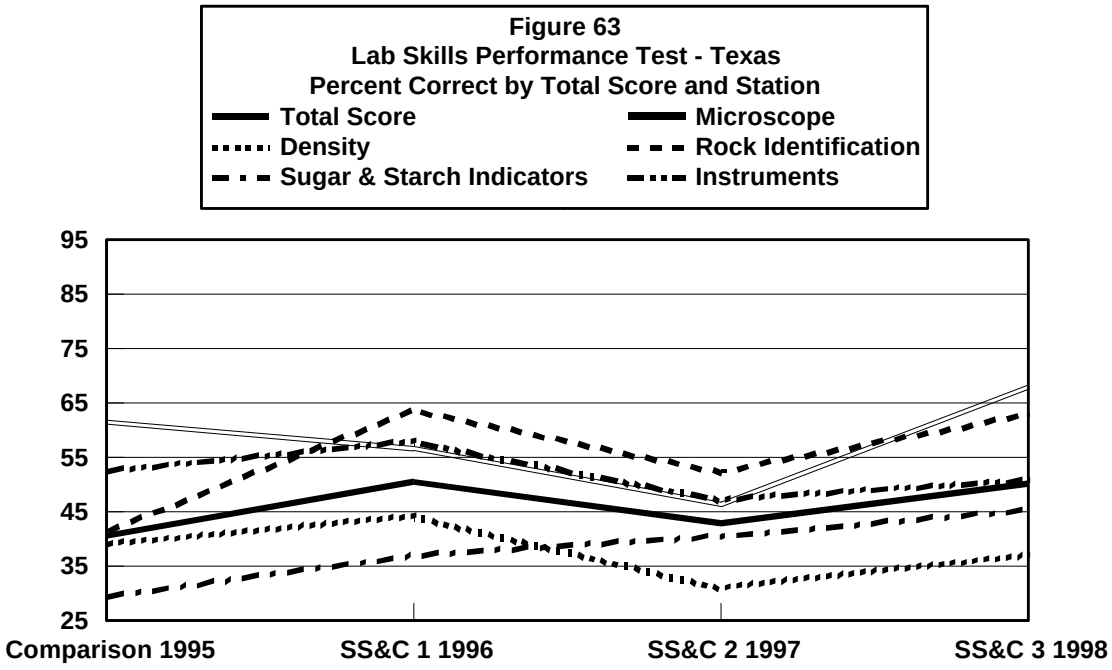




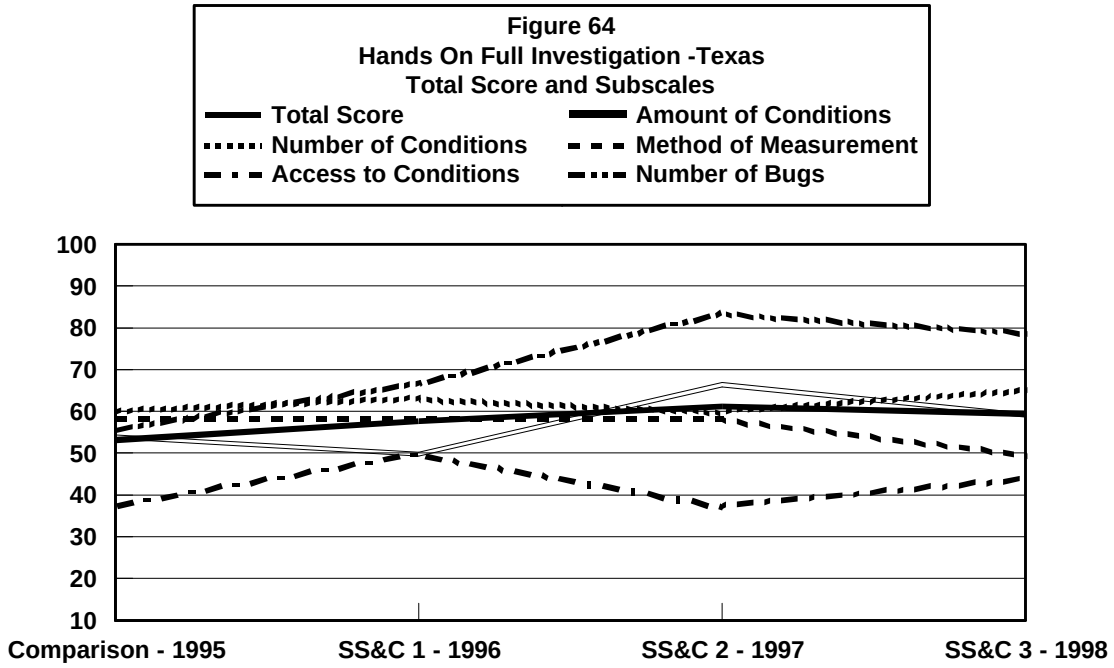
The students significantly increased their belief in science's usefulness the first year but this then decreased although student perception of the relation of what you learn in science to the real world and the usefulness of it in the future significantly increased and remained high all three years. (See Figure 61 and Table 61). The first year showed an increase in student motivation for science with significant increases in perceptions of science classes being interesting and fun that remained for the three years.



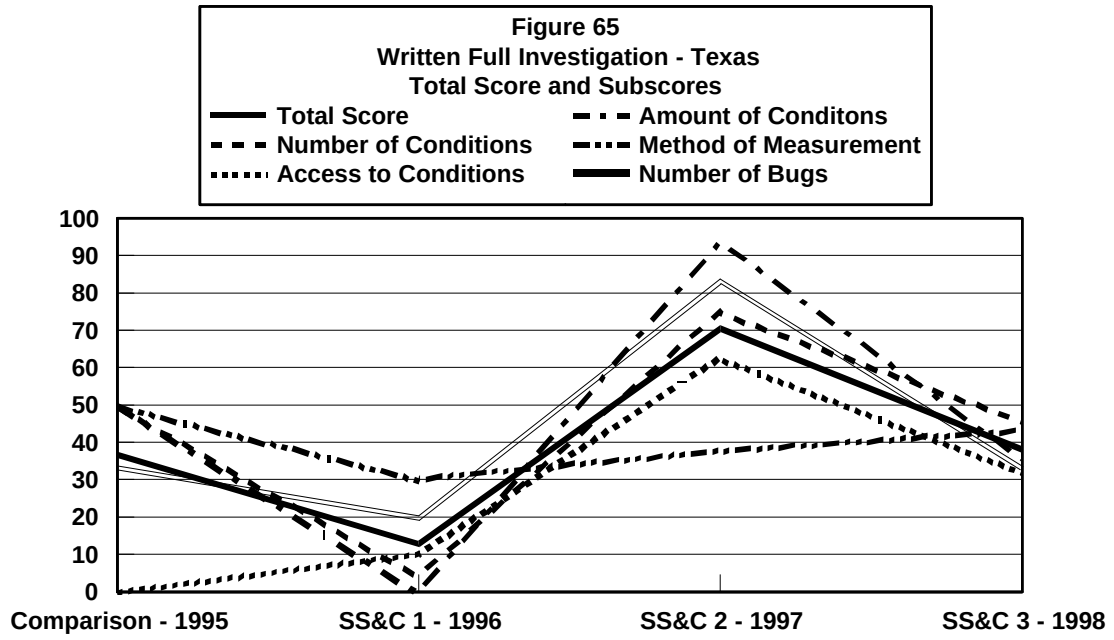
There were slight increases on the earth and space science and science in personal and social perspectives scales the first year, a significant drop the second year in total score and on six of the seven scales to below the comparison year and an increase to original comparison year levels the third year. (See Figure 62 and Table 62).



Taken together the laboratory skills test showed increases the first year with significant improvement in total score and rock identification, decreases to the original levels the second year and significant increases again the third year in total score, rock identification and indicators. (See Figure 63 and Table 63).



The hands on full investigation went up very slightly each year. (See Figure 64 and Table 64). Because only a small number of students completed the written full investigation there were no significant differences over the years despite the large difference in scores shown on the chart. (See Figure 65 and Table 65).



Concluding Remarks

As can be seen in the trend data, science achievement shows an increase for the first year of SS&C, then in the second year the achievement went down. This may have been because the teachers were frustrated with trying to meet the requirements of the curriculum with no external support. For the 97-98 year the scores go up a little to the pre SS&C levels. This may reflect the teachers returning to their preferred styles and what was most comfortable to them. The rise in student achievement in the first year is accompanied by a rise in student centered teaching behaviors (in accordance with the philosophy of SS&C) for the 96 year. The 97 year shows some drop off or at least steady state of these student centered behaviors but a clear drop by 98. One interpretation is that the teachers were attempting to implement SS&C as it should be in a student centered manner. However, they were unable to carry it out effectively and were frustrated by the second year and this showed up in the lower scores of the students. By the 98 year the teachers were doing what they wanted and were comfortable in a less student centered approach so the students' scores went up some but not to the levels of when the teachers were using the SS&C style.

Appendix:

Evaluating the Long Term Effects of Teacher Enhancement

January, 1999

Frances Lawrenz
Douglas Huffman

University of Minnesota

TABLE OF CONTENTS

Table 1
New York
Classroom Observations
Percent Time Spent by Teaching Style

Style	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 3		n = 6		n = 3		n = 7	
	freq.	%	freq.	%	freq.	%	freq.	%
Teacher Centered	0	0.00	5	11.90	1	4.00	8	18.18
Student & Teacher Centered	20	76.92	15	35.71	6	24.00	9	20.45
Student Centered	1	3.85	12	28.57	13	52.00	23	52.27
Administrative	5	19.23	6	14.29	5	20.00	2	4.55
Other activities	0	0.00	4	9.52	0	0.00	2	4.55

Statistical Tests

Style	1995 vs. 1996		1995 vs. 1997		1995 vs. 1998	
	X^2	p	X^2	p	X^2	p
Teacher Centered						
Student & Teacher Centered						
Student Centered						
Administrative						
Other activities						
	24.27	<.01	18.54	<.01	39.96	<.01

Table 2
New York
Learning Environment Inventory
Student Means

Subscale	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 10		n = 13		n = 16		n = 15	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Difficulty	3.23	0.22	2.70	0.21	2.73	.20	2.71	0.19
Relevance	3.86	0.32	3.89	0.17	3.36	.19	3.56	0.23
Critical Voice	4.20	0.16	3.76	0.18	3.84	.16	3.76	0.18
Involvement	4.26	0.20	3.79	0.23	3.87	.13	3.91	0.14
Sequencing	1.85	0.12	2.69	0.18	2.67	.25	2.20	0.15
Experimenting	2.38	0.21	2.28	0.19	2.60	.15	2.61	0.21

1 = Almost Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Almost Always

Statistical Tests

Subscale	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Difficulty	-0.53	1.75	.10	-0.50	1.65	.11	-0.52	1.80	.09
Relevance	0.03	-0.09	.93	-0.50	1.43	.16	-0.30	0.80	.43
Critical Voice	-0.44	1.75	.09	-0.36	1.49	.15	-0.44	1.71	.10
Involvement	-0.47	1.47	.16	-0.39	1.69	.10	-0.35	1.47	.15
Sequencing	0.84	-3.62	<.01	0.82	-2.49	.02	0.35	-1.64	.12
Experimenting	-0.10	0.37	.72	0.22	-0.85	.40	0.23	-0.75	.46

Table 3
New York
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 8		n = 12		n = 13		n = 13	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Work in groups	2.20	0.29	4.46	0.18	4.50	0.14	3.80	0.24
Do experiments with other students	2.50	0.34	4.38	0.18	4.14	0.18	3.67	0.27
Ask students to suggest hypotheses	3.90	0.46	3.50	0.44	4.20	0.17	3.40	0.38
Share results from experiments	3.30	0.42	4.08	0.24	3.86	0.33	3.57	0.36
Ask for reasons for the results of experiments	4.20	0.36	4.46	0.24	4.47	0.24	4.00	0.22
Ask students to interpret data	3.78	0.43	3.69	0.26	3.43	0.31	3.60	0.29

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Work in groups	2.26	-6.88	<.01	2.30	-7.82	<.01	1.60	-4.20	.01
Do experiments with other students	1.88	-5.20	<.01	1.64	-4.62	<.01	1.17	-2.70	.01
Ask students to suggest hypotheses	-0.40	0.63	.54	0.30	-0.70	.49	-0.50	0.84	.41
Share results from experiments	0.78	-1.69	.11	0.56	-1.06	.30	0.27	-0.49	.63
Ask for reasons for the results of experiments	0.26	-0.62	.54	0.27	-0.65	.52	-0.20	0.51	.62
Ask students to interpret data	-0.09	0.18	.86	-0.35	0.67	.51	-0.18	0.35	.73

Table 4
New York
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 8		n = 12		n = 13		n = 13	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Work on projects	1.40	0.22	2.23	0.28	2.36	0.37	2.60	0.40
Read science textbook	2.20	0.13	1.23	0.12	1.36	0.25	1.27	0.15
Read articles on science	1.70	0.26	1.92	0.26	2.57	0.29	1.47	0.22
Do oral or written reports	1.20	0.13	1.62	0.18	1.57	0.20	1.60	0.19
Read other science materials	2.80	0.57	2.38	0.24	2.79	0.30	1.93	0.35

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Work on projects	0.83	-2.21	.04	0.96	-1.99	.06	1.20	-2.29	.03
Read science textbook	-0.97	5.34	<.01	-0.84	2.67	.01	-0.93	4.29	<.01
Read articles on science	0.22	-0.59	.56	0.87	-2.13	.05	-0.23	0.69	.50
Do oral or written reports	0.42	-1.75	.09	0.37	-1.40	.18	0.40	-1.55	.14
Read other science materials	-0.42	0.73	.48	-0.01	0.02	.98	-0.87	1.36	.19

Table 5
New York
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 8		n = 12		n = 13		n = 13	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Lecture	2.80	0.53	2.77	0.36	3.21	0.38	3.33	0.42
Demonstration of a scientific principle	3.22	0.60	3.85	0.32	3.73	0.30	3.73	0.30
Relate previous work to current topic	3.80	0.44	3.38	0.27	3.47	0.22	3.07	0.42
Go outside for class instruction	1.20	0.13	1.77	0.20	1.71	0.27	2.20	0.38
Watch films, slides, or videos	2.40	0.16	2.31	0.21	2.29	0.19	2.13	0.22

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Lecture	-0.03	0.05	.96	0.41	-0.65	.52	0.53	-0.79	.44
Demonstration of a scientific principle	0.63	-1.00	.33	0.51	-0.85	.40	0.51	-0.85	.40
Relate previous work to current topic	-0.42	0.85	.41	-0.33	0.75	.46	-0.73	1.17	.26
Go outside for class instruction	0.57	-2.21	.04	0.51	-1.53	.14	1.00	-2.08	.05
Watch films, slides, or videos	-0.09	0.33	.74	-0.11	0.43	.68	-0.27	0.90	.38

Table 6
New York
Student Questionnaire
Class Means
Percent of Students Who Have Participated in Science Activities Outside of Class

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 10		n = 13		n = 15		n = 14	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Talk about what you learn in science class	60.00	16.33	69.23	13.32	73.33	11.82	33.33	12.60
Watch a science program on TV	90.00	10.00	69.23	13.32	80.00	10.69	21.43	11.38
Go bird watching	10.00	10.00	15.38	10.42	6.67	6.67	6.67	6.67
Go to a science museum	40.00	16.33	61.54	14.04	26.67	11.82	46.67	13.33
Talk about science topics	60.00	16.33	61.54	14.04	66.67	12.60	20.00	10.69

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Talk about what you learn in science class	9.23	0.44	.66	13.33	0.66	.51	-26.67	-1.29	.20
Watch a science program on TV	-20.77	-1.25	.21	-10.00	-0.68	.50	-68.57	-4.53	<.01
Go bird watching	5.38	0.37	.71	-3.33	-0.28	.78	-3.33	-0.28	.78
Go to a science museum	21.54	1.00	.32	-13.33	-0.66	.51	6.67	0.32	.75
Talk about science topics	1.54	0.07	.94	6.67	0.32	.75	-40.00	-2.05	.04

Table 6 - New York: Student Questionnaire
Percent of Students Who Have Participated in Science Activities Outside of Class (continued)

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 10		n = 13		n = 15		n = 14	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Build a telescope	0.00	0.00	0.00	0.00	6.67	6.67	0.00	0.00
Read books about science	30.00	15.28	38.46	14.04	33.33	12.60	13.33	9.09
Do a science experiment	70.00	15.28	53.85	14.39	40.00	13.09	40.00	13.09
Write an article for a science journal	10.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
Read a science magazine	40.00	16.33	23.08	12.16	100.00	51.64	20.00	10.69

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Build a telescope	0.00	0.00	1.00	6.67	1.00	.32	0.00	0.00	1.00
Read books about science	8.46	0.41	.68	3.33	0.17	.87	-16.67	-0.94	.35
Do a science experiment	-16.15	-0.77	.44	-30.00	-1.49	.14	-30.00	-1.49	.14
Write an article for a science journal	-10.00	-1.00	.32	-10.00	-1.00	.32	-10.00	-1.00	.32
Read a science magazine	-16.92	-0.83	.41	60.00	1.11	.27	-20.00	-1.02	.31

Table 7
New York
Student Questionnaire
Class Means
Inclination to Continue Studying Science

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 10		n = 9		n = 11		n = 14	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Take a science class in 10th grade	90.00	10.00	92.31	7.69	100.00	0.00	100.00	0.00
Take a science class in 11th grade	90.00	10.00	92.31	7.69	100.00	0.00	93.33	6.67
Take a science class in 12th grade	80.00	13.33	58.33	14.86	85.71	9.71	80.00	10.69
Take a science class in college	60.00	16.33	70.00	15.28	64.29	13.29	57.14	13.73

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Take a science class in 10th grade	2.31	0.18	.86	10.00	1.00	.32	10.00	1.00	.32
Take a science class in 11th grade	2.31	0.18	.86	10.00	1.00	.32	3.33	0.28	.78
Take a science class in 12th grade	-21.67	-1.09	.28	5.71	0.35	.73	0.00	0.00	1.00
Take a science class in college	10.00	0.45	.65	4.29	0.20	.84	-2.86	-0.13	.90

Table 8
New York
Student Questionnaire
Class Means
Science Motivation

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 10		n = 9		n = 11		n = 14	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Do you think you will pursue a career in science?	20.00	13.33	25.00	13.06	7.14	7.14	20.00	10.69
Have activities in science class made you want to take more science?	70.00	15.28	69.23	13.32	73.33	11.82	40.00	13.09
Is your science class motivating?	80.00	13.33	91.67	8.33	78.57	11.38	40.00	13.09
Have you ever had a "totally awesome" experience in your science class?	70.00	15.28	83.33	11.24	64.29	13.29	53.33	13.33

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Do you think you will pursue a career in science?	5.00	0.27	.79	-12.86	-0.85	.40	0.00	0.00	1.00
Have activities in science class made you want to take more science?	-0.77	-0.04	.97	3.33	0.17	.87	-30.00	-1.49	.14
Is your science class motivating?	11.67	0.74	.46	-1.43	-0.08	.94	-40.00	-2.14	.03
Have you ever had a "totally awesome" experience in your science class?	13.33	0.70	.48	-5.71	-0.28	.78	-16.67	-0.82	.41

Table 9 - New York
Student Questionnaire - Class Means - Students' Attitudes toward Science

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 10		n = 13		n = 14		n = 14	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Science is useful to me outside of class.	3.40	0.54	3.62	0.31	3.33	0.30	3.00	0.26
The things you learn in science relate to the real world.	4.10	0.41	4.46	0.22	4.40	0.13	3.33	0.35
Much of what you learn in science classes will be useful in the future.	4.10	0.23	4.08	0.24	3.93	0.29	3.47	0.29
It is important to know some science in order to get a good job.	3.70	0.21	3.54	0.31	3.53	0.24	3.64	0.17
Science class is interesting.	4.00	0.39	3.69	0.29	3.80	0.20	2.80	0.37
Science class is fun.	4.00	0.42	3.46	0.29	3.67	0.16	3.67	0.30

1 = Strongly Disagree, 2 = Disagree, 3 = No Opinion, 4 = Agree, 5 = Strongly Agree

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Science is useful to me outside of class.	0.22	-0.36	.72	-0.07	0.12	.91	-0.40	0.74	.47
The things you learn in science relate to the real world.	0.36	-0.84	.41	0.30	-0.82	.42	-0.77	1.42	.17
Much of what you learn in science classes will be useful in the future.	-0.02	0.07	.95	-0.17	0.44	.67	-0.63	1.56	.13
It is important to know some science in order to get a good job.	-0.16	0.40	.69	-0.17	0.49	.63	-0.06	0.21	.83
Science class is interesting.	-0.31	0.65	.52	-0.20	0.50	.62	-1.20	2.17	.04
Science class is fun.	-0.54	1.09	.29	-0.33	0.85	.41	-0.33	0.66	.52

Table 10
New York
Science Literacy Test
Student Means
Percent Correct on Multiple Choice Items

Standard	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 26		n = 31		n = 41		n = 23	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	45.43	2.58	51.33	2.22	48.45	1.87	51.90	3.01
Science as Inquiry	47.20	3.52	55.72	3.38	49.67	2.44	52.96	4.63
Physical Science	41.67	3.64	51.88	3.68	48.37	3.01	53.26	4.03
Life Science	48.08	3.64	57.53	2.76	52.44	2.52	57.97	3.32
Earth & Space Sciences	37.50	2.90	37.63	2.63	39.63	2.58	41.67	3.64
Science & Technology	46.15	3.36	51.21	3.14	49.39	2.80	45.65	3.86
Science in Personal & Social Perspectives	36.54	4.82	42.20	3.85	39.63	3.02	49.28	5.45
History & Nature of Science	60.06	3.41	62.53	3.21	59.47	2.68	49.87	3.29

Statistical Tests

Standard	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	5.90	1.73	.08	3.01	0.94	.35	6.47	1.63	.10
Science as Inquiry	8.52	1.75	.08	2.46	0.58	.56	5.76	0.99	.32
Physical Science	10.22	1.97	.05	6.71	1.42	.16	11.59	2.13	.03
Life Science	9.45	2.07	.04	4.36	0.99	.32	9.89	2.01	.04
Earth & Space Sciences	0.13	0.03	.98	2.13	0.55	.58	4.17	0.90	.37
Science & Technology	5.06	1.10	.27	3.24	0.74	.46	-0.50	-0.10	.92
Science in Personal & Social Perspectives	5.67	0.92	.36	3.10	0.54	.59	12.74	1.75	.08
History & Nature of Science	2.47	0.53	.60	-0.58	-0.13	.90	-10.19	-2.15	.03

Table 11
New York
Lab Skills Performance Test
Student Means
Percent Correct by Total Score and Station

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 12		n = 10		n = 9		n = 18	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	40.97	5.47	59.14	5.83	63.27	6.14	58.80	4.03
Density	33.07	7.72	47.50	7.53	54.28	12.14	43.00	7.62
Sugar & Starch Indicators	40.59	6.14	45.28	10.22	64.51	8.71	58.74	7.31
Microscope	62.50	8.67	64.17	13.03	54.63	9.53	56.48	3.96
Rock Identification	46.30	9.67	73.61	8.85	76.23	7.65	78.09	5.72
Instruments	36.11	7.27	74.67	5.86	55.56	7.11	50.37	4.22

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	18.17	2.27	.02	22.30	2.71	.01	17.82	2.62	.01
Density	14.43	1.34	.18	21.21	1.47	.14	9.92	0.91	.36
Sugar & Starch Indicators	4.69	0.39	.70	23.92	2.24	.03	18.16	1.90	.06
Microscope	1.67	0.11	.91	-7.87	-0.61	.54	-6.02	-0.63	.53
Rock Identification	27.31	2.08	.04	29.94	2.43	.02	31.79	2.83	<.01
Instruments	38.56	4.13	<.01	19.44	1.91	.06	14.26	1.70	.09

Table 12
New York
Hands On Full Investigation
Student Means
Percent Correct by Total Score and Station

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 6		n = 3		n = 4		n = 5	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	48.44	7.22	46.11	21.17	54.58	12.95	54.73	10.93
Number of Conditions	36.67	14.98	66.67	24.04	50.00	5.77	52.00	14.97
Access to Conditions	37.50	5.59	16.67	16.67	50.00	10.21	55.00	14.58
Amount of Conditions	54.17	15.02	58.33	30.05	56.25	21.35	60.00	15.00
Method of Measurement	58.33	8.33	33.33	16.67	50.00	28.87	60.00	10.00
Number of Bugs	55.56	7.03	55.56	29.40	66.67	13.61	46.67	8.17

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	-2.33	-0.10	.92	6.14	0.41	.68	6.29	0.48	.63
Number of Conditions	30.00	1.06	.29	13.33	0.83	.41	15.33	0.72	.47
Access to Conditions	-20.83	-1.18	.24	12.50	1.07	.28	17.50	1.12	.26
Amount of Conditions	4.16	0.12	.90	2.08	0.08	.94	5.83	0.27	.79
Method of Measurement	-25.00	-1.34	.18	-8.33	-0.28	.78	1.67	0.13	.90
Number of Bugs	1.00	0.03	.98	11.11	0.73	.47	-8.89	-0.82	.41

Table 13
New York
Written Full Investigation
Student Means
Percent Correct by Total Score and Subscores

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 5		n = 3		n = 4		n = 5	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	40.00	11.49	74.89	13.75	84.58	6.02	63.27	12.03
Number of Conditions	40.00	10.95	80.00	20.00	100.00	0.00	68.00	20.59
Access to Conditions	35.00	10.00	66.67	16.67	68.75	6.25	50.00	15.81
Amount of Conditions	35.00	18.71	83.33	16.67	100.00	0.00	75.00	15.81
Method of Measurement	30.00	12.25	66.67	33.33	62.50	23.94	30.00	20.00
Number of Bugs	60.00	16.33	77.78	11.11	91.67	8.33	93.33	6.67

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	34.89	1.95	.05	44.58	3.44	<.01	23.27	1.40	.16
Number of Conditions	40.00	1.75	.08	60.00	5.48	<.01	28.00	1.20	.23
Access to Conditions	31.67	1.63	.10	33.75	2.86	<.01	15.00	0.80	.42
Amount of Conditions	48.33	1.93	.05	-25.00	-1.34	.18	40.00	1.63	.10
Method of Measurement	36.67	1.03	.30	32.50	1.21	.23	0.00	0.00	1.00
Number of Bugs	17.78	0.90	.37	31.67	1.73	.08	33.33	1.89	.06

Table 14
Montana
Classroom Observations
Percent Time Spent by Teaching Style

Style	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 7		n = 6		n = 3		n = 6	
	freq.	%	freq.	%	freq.	%	freq.	%
Teacher Centered	46	68.66	10	16.13	0	0.00	4	6.90
Student & Teacher Centered	11	16.42	11	17.74	1	3.57	7	12.07
Student Centered	3	4.48	32	51.61	25	89.29	41	70.64
Administrative	7	10.45	9	14.52	2	7.14	6	10.34
Other activities	0	0.00	0	0.00	0	0.00	0	0.00

Statistical Tests

Style	1995 vs. 1996		1995 vs. 1997		1995 vs. 1998	
	X^2	p	X^2	p	X^2	p
Teacher Centered						
Student & Teacher Centered						
Student Centered						
Administrative						
Other activities						
	47.32	<.01	69.86	<.01	68.86	<.01

Table 15
Montana
Learning Environment Inventory
Student Means

Subscale	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 236		n = 103		n = 83		n = 142	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Difficulty	3.16	0.05	2.92	0.07	2.94	0.08	2.95	0.07
Relevance	3.46	0.05	3.38	0.08	3.33	0.09	3.36	0.07
Critical Voice	3.52	0.05	3.69	0.07	3.28	0.08	3.41	0.07
Involvement	3.64	0.05	3.72	0.06	3.53	0.08	3.59	0.05
Sequencing	2.59	0.05	2.81	0.08	3.06	0.10	2.85	0.07
Experimenting	2.46	0.04	2.36	0.06	2.21	0.07	2.29	0.05

1 = Almost Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Almost Always

Statistical Tests

Subscale	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Difficulty	-0.24	2.50	.01	-0.22	2.09	.04	-0.21	2.40	.02
Relevance	-0.08	0.85	.40	-0.13	1.26	.21	-0.10	1.16	.25
Critical Voice	0.17	-1.99	.05	-0.24	2.60	.01	-0.11	1.38	.17
Involvement	0.08	-1.03	.30	-0.11	1.24	.22	-0.05	0.70	.49
Sequencing	0.22	-2.47	.01	0.47	-4.86	<.01	0.26	-3.19	<.01
Experimenting	-.10	1.41	.16	-0.25	3.13	<.01	-0.17	2.52	<.01

Table 16
Montana
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 229		n = 92		n = 82		n = 139	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Work in groups	3.64	0.07	4.06	0.09	3.71	0.13	3.87	0.09
Do experiments with other students	2.57	0.06	4.16	0.07	3.98	0.11	3.96	0.08
Ask students to suggest hypotheses	3.20	0.07	4.07	0.11	3.86	0.12	4.03	0.10
Share results from experiments	2.97	0.07	3.73	0.10	3.57	0.13	3.50	0.09
Ask for reasons for the results of experiments	3.44	0.07	3.99	0.09	3.90	0.11	4.15	0.07
Ask students to interpret data	3.49	0.07	3.74	0.12	3.49	0.13	3.87	0.09

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Work in groups	0.42	-3.57	<.01	0.07	-0.50	.62	0.23	-2.09	.04
Do experiments with other students	1.59	-16.03	<.01	1.41	-12.19	<.01	1.39	-14.56	<.01
Ask students to suggest hypotheses	0.87	-6.74	<.01	0.66	-4.66	<.01	0.83	-7.00	<.01
Share results from experiments	0.76	-6.29	<.01	0.66	-4.34	<.01	0.53	-4.75	<.01
Ask for reasons for the results of experiments	0.55	-4.66	<.01	0.46	-3.57	<.01	0.71	-7.04	<.01
Ask students to interpret data	0.25	-1.88	.06	0.00	-0.02	.99	0.38	-3.37	<.01

Table 17
Montana
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 229		n = 92		n = 82		n = 139	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Work on projects	2.92	0.07	3.05	0.14	3.07	0.17	2.68	0.13
Read science textbook	2.20	0.05	1.34	0.09	1.06	0.04	1.06	0.02
Read articles on science	2.64	0.07	2.03	0.09	2.05	0.12	1.87	0.08
Do oral or written reports	1.89	0.04	1.55	0.10	1.42	0.08	1.46	0.06
Read other science materials	2.94	0.07	2.44	0.13	2.59	0.16	2.19	0.10

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Work on projects	0.13	-0.89	.37	0.15	-0.96	.34	-0.24	1.80	.07
Read science textbook	-0.86	8.53	<.01	-1.14	12.53	<.01	-1.14	16.27	<.01
Read articles on science	-0.61	5.13	<.01	-0.59	4.38	<.01	-0.77	7.24	<.01
Do oral or written reports	-0.34	3.77	<.01	-0.47	5.69	<.01	-0.43	6.24	<.01
Read other science materials	-0.50	3.56	<.01	-0.35	2.24	.03	-0.75	6.07	<.01

Table 18
Montana
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 229		n = 92		n = 82		n = 139	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Lecture	3.54	0.07	3.34	0.12	3.22	0.15	3.50	0.10
Demonstration of a scientific principle	3.08	0.06	3.36	0.10	3.25	0.11	3.12	0.08
Relate previous work to current topic	3.21	0.07	3.44	0.11	3.36	0.13	3.56	0.10
Go outside for class instruction	2.11	0.05	1.67	0.07	1.23	0.06	1.34	0.07
Watch films, slides. or videos	2.68	0.05	2.35	0.07	2.54	0.06	2.32	0.06

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Lecture	-0.02	1.49	.14	-0.32	2.14	.03	-0.04	0.37	.72
Demonstration of a scientific principle	0.28	-2.33	.02	0.17	-1.35	.18	0.04	-0.37	.71
Relate previous work to current topic	0.23	-1.72	.09	0.15	-1.02	.31	0.35	-2.89	<.01
Go outside for class instruction	-0.44	5.02	<.01	-0.88	9.68	<.01	-0.77	9.49	<.01
Watch films, slides. or videos	-0.33	3.74	<.01	-0.14	1.53	.13	-0.36	4.41	<.01

Table 19
Montana
Student Questionnaire
Class Means
Percent of Students Who Have Participated in Science Activities Outside of Class

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 234		n = 101		n = 81		n = 142	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Talk about what you learn in science class	65.96	3.10	65.69	4.72	53.01	5.51	51.41	4.21
Watch a science program on TV	54.47	3.26	60.19	4.85	50.00	5.56	61.97	4.09
Go bird watching	14.47	3.30	14.56	3.49	20.73	4.50	16.20	3.10
Go to a science museum	34.62	3.12	34.95	4.72	25.30	4.80	30.99	3.89
Talk about science topics	54.27	3.26	59.41	4.91	46.99	5.51	48.59	4.21

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Talk about what you learn in science class	-0.27	-0.05	.96	-12.95	-2.05	.04	-14.55	-2.78	.01
Watch a science program on TV	5.72	0.98	.33	-4.47	-0.69	.49	7.50	1.43	.15
Go bird watching	0.09	0.02	.98	-12.40	-2.22	.03	1.73	0.38	.70
Go to a science museum	0.33	0.06	.95	-9.32	-1.63	.10	-3.63	-0.73	.47
Talk about science topics	5.14	0.87	.38	-7.28	-1.14	.25	-5.68	-1.07	.28

Table 19 – Montana: Student Questionnaire
Percent of Students Who Have Participated in Science Activities Outside of Class (continued)

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 234		n = 101		n = 81		n = 142	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Build a telescope	2.99	1.12	2.91	1.67	1.20	1.20	1.41	0.99
Read books about science	28.63	2.96	24.27	4.25	29.27	5.06	22.54	3.52
Do a science experiment	34.47	3.11	33.98	4.69	36.14	5.31	26.06	3.70
Write an article for a science journal	3.83	1.25	6.80	2.49	1.20	1.20	1.41	0.99
Read a science magazine	37.45	3.16	47.57	4.94	30.86	5.16	33.80	3.98

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Build a telescope	-0.08	-0.04	.97	-1.79	-1.09	.28	-1.58	-1.06	.29
Read books about science	-4.36	-0.84	.40	0.64	0.11	.91	-6.09	-1.32	.19
Do a science experiment	-0.49	-0.09	.93	1.67	0.27	.79	-8.41	-1.74	.08
Write an article for a science journal	2.97	1.07	.28	-2.63	-1.52	.13	-2.42	-1.52	.13
Read a science magazine	10.12	1.73	.08	-6.59	-1.09	.28	-3.65	-0.72	.47

Table 20
Montana
Student Questionnaire
Class Means
Inclination to Continue Studying Science

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 206		n = 87		n = 73		n = 133	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Take a science class in 10th grade	93.16	1.65	89.22	3.07	92.68	2.89	91.55	2.34
Take a science class in 11th grade	73.57	2.93	71.29	4.52	70.37	5.11	76.60	3.58
Take a science class in 12th grade	46.61	3.36	46.39	5.09	61.54	11.13	41.30	4.21
Take a science class in college	54.22	3.33	47.87	5.18	52.50	5.62	49.26	4.30

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Take a science class in 10th grade	-3.94	-1.13	.26	-0.48	-0.14	.89	-1.61	-0.56	.58
Take a science class in 11th grade	-2.28	-0.42	.67	-3.20	-0.54	.59	3.03	0.65	.52
Take a science class in 12th grade	-0.22	-0.04	.97	14.93	1.28	.20	-5.31	-0.99	.32
Take a science class in college	-6.35	-1.03	.30	-1.72	-0.26	.79	-4.96	-0.91	.36

Table 21
Montana
Student Questionnaire
Class Means
Science Motivation

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 206		n = 87		n = 73		n = 133	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Do you think you will pursue a career in science?	28.88	2.98	23.23	4.27	30.49	5.12	24.11	3.62
Have activities in science class made you want to take more science?	32.90	3.10	41.58	4.93	60.24	13.92	35.21	4.02
Is your science class motivating?	46.09	3.29	57.43	4.94	55.56	5.56	43.97	4.19
Have you ever had a "totally awesome" experience in your science class?	41.03	3.22	59.22	4.87	48.19	5.52	46.48	4.20

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Do you think you will pursue a career in science?	-5.65	-1.09	.28	1.61	0.27	.79	-4.77	-1.02	.31
Have activities in science class made you want to take more science?	8.68	1.49	.14	27.34	1.92	.13	2.31	0.46	.65
Is your science class motivating?	11.34	1.91	.06	9.47	1.47	.14	-2.12	-0.40	.69
Have you ever had a "totally awesome" experience in your science class?	18.19	3.12	<.01	7.16	1.12	.26	5.45	1.03	.30

Table 22 - Montana
Student Questionnaire - Class Means - Students' Attitudes toward Science

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 234		n = 99		n = 83		n = 141	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Science is useful to me outside of class.	3.40	0.07	3.31	0.11	3.37	0.13	3.12	0.10
The things you learn in science relate to the real world.	4.01	0.06	4.00	0.09	4.04	0.11	3.93	0.09
Much of what you learn in science classes will be useful in the future.	3.66	0.07	3.78	0.10	3.64	0.11	3.50	0.09
It is important to know some science in order to get a good job.	3.77	0.06	3.74	0.09	3.75	0.09	3.80	0.07
Science class is interesting.	2.68	0.07	3.04	0.11	2.94	0.15	2.82	0.10
Science class is fun.	2.93	0.07	3.11	0.10	3.06	0.14	3.04	0.09

1 = Strongly Disagree, 2 = Disagree, 3 = No Opinion, 4 = Agree, 5 = Strongly Agree

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Science is useful to me outside of class.	-0.09	0.67	.51	-0.03	0.18	.86	-0.28	2.29	.02
The things you learn in science relate to the real world.	-0.01	0.08	.94	0.03	-0.22	.82	-0.08	0.76	.45
Much of what you learn in science classes will be useful in the future.	0.12	-0.91	.37	-0.02	0.19	.85	-0.16	1.45	.15
It is important to know some science in order to get a good job.	-0.03	0.32	.75	-0.02	0.21	.83	0.03	-0.28	.78
Science class is interesting.	0.36	-2.71	.01	0.26	-1.72	.09	0.14	-1.18	.24
Science class is fun.	0.18	-1.42	.16	0.13	-0.91	.37	0.11	-0.93	.35

Table 23
Montana
Science Literacy Test
Student Means
Percent Correct on Multiple Choice Items

Standard	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 288		n = 126		n = 91		n = 149	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	61.39	0.82	61.00	1.19	60.40	1.35	61.85	0.98
Science as Inquiry	65.88	1.15	65.58	1.76	64.14	2.02	66.75	1.54
Physical Science	61.49	1.23	61.38	1.89	61.54	2.24	65.44	1.57
Life Science	62.73	1.08	63.03	1.67	65.57	1.70	65.94	1.29
Earth & Space Sciences	53.73	1.06	53.24	1.53	52.20	1.49	50.56	1.13
Science & Technology	53.13	1.09	52.08	1.65	50.41	1.89	53.02	1.45
Science in Personal & Social Perspectives	61.28	1.13	60.45	1.99	58.15	2.01	60.46	1.68
History & Nature of Science	68.54	0.93	68.07	1.44	67.20	1.52	67.79	1.36

Statistical Tests

Standard	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	-0.39	-0.27	.79	-0.99	-0.63	.53	0.46	0.36	.72
Science as Inquiry	-0.29	-0.14	.89	-1.74	-0.75	.45	0.87	0.45	.65
Physical Science	-0.11	-0.05	.96	0.05	0.02	.98	3.95	1.98	.05
Life Science	0.30	0.15	.88	2.84	1.41	.16	3.21	1.91	.06
Earth & Space Sciences	-0.49	-0.26	.79	-1.53	-0.84	.40	-3.17	-2.04	.04
Science & Technology	-1.04	-0.53	.60	-2.71	-1.24	.22	-0.10	-0.06	.95
Science in Personal & Social Perspectives	-0.84	-0.37	.71	-3.13	-1.36	.17	-0.83	-0.41	.68
History & Nature of Science	-0.47	-0.27	.79	-1.33	-0.74	.46	-0.75	-0.45	.65

Table 24
Montana
Lab Skills Performance Test
Student Means
Percent Correct by Total Score and Station

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 27		n = 28		n = 14		n = 15	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	68.34	3.35	76.80	2.33	82.05	2.73	75.39	4.10
Density	67.48	4.00	81.55	2.93	75.74	6.61	73.96	6.96
Sugar & Starch Indicators	59.19	5.89	72.52	4.82	82.47	4.58	66.11	7.65
Microscope	71.91	6.04	86.01	4.20	93.45	4.30	87.22	5.07
Rock Identification	77.98	4.08	83.63	2.54	90.08	2.58	84.44	7.24
Instruments	67.41	2.50	60.95	3.62	72.38	3.62	73.33	2.25

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	8.46	2.07	.04	13.71	3.17	<.01	7.05	1.33	.18
Density	14.07	2.84	<.01	8.27	1.07	.28	6.48	0.81	.42
Sugar & Starch Indicators	13.33	1.75	.08	23.28	3.12	<.01	6.92	0.72	.47
Microscope	44.10	6.00	<.01	51.54	6.96	<.01	45.31	5.75	<.01
Rock Identification	1.18	0.24	12.10	12.10	2.51	.01	6.46	0.78	.44
Instruments	-1.47	0.14	4.97	4.97	1.13	.26	5.93	1.76	.08

Table 25
Montana
Hands On Full Investigation
Student Mean
Percent Correct by Total Score and Station

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 6		n = 6		n = 6		n = 6	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	59.00	13.33	86.39	3.37	65.11	7.91	88.33	3.57
Number of Conditions	53.33	13.33	100.00	0.00	53.33	16.87	100.00	0.00
Access to Conditions	50.00	14.43	62.50	20.16	62.50	8.54	83.33	8.33
Amount of Conditions	66.67	15.37	91.67	5.27	62.50	14.07	83.33	5.27
Method of Measurement	58.33	17.37	100.00	0.00	75.00	11.18	91.67	8.33
Number of Bugs	66.67	14.91	77.78	7.03	72.22	10.24	83.33	7.45

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	27.39	1.99	.05	6.11	0.39	.70	29.33	2.13	.03
Number of Conditions	46.67	3.50	<.01	0.00	0.00	1.00	46.67	3.50	.00
Access to Conditions	12.50	0.50	.62	12.50	0.75	.45	33.33	2.00	.05
Amount of Conditions	25.00	1.54	.12	-4.17	-0.20	.84	16.66	1.03	.30
Method of Measurement	41.67	2.40	.02	16.67	0.81	.42	33.34	1.73	.08
Number of Bugs	11.11	0.67	.50	5.55	0.31	.76	16.66	1.00	.32

Table 26
Montana
Written Full Investigation
Student Means
Percent Correct by Total Score and Subscores

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 6		n = 6		n = 4		n = 6	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	59.06	13.40	79.17	9.23	80.50	10.65	79.44	5.12
Number of Conditions	63.33	17.45	83.33	16.67	90.00	10.00	100.00	0.00
Access to Conditions	58.33	15.37	62.50	15.48	87.50	7.22	75.00	11.18
Amount of Conditions	62.50	15.48	83.33	16.67	100.00	0.00	100.00	0.00
Method of Measurement	33.33	21.08	83.33	16.67	50.00	28.87	33.33	21.08
Number of Bugs	77.78	16.48	83.33	7.45	75.00	15.96	88.89	7.03

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	20.11	1.79	.07	21.44	1.73	.08	20.38	2.49	.02
Number of Conditions	20.00	0.83	.41	26.67	1.33	.18	36.67	2.10	.04
Access to Conditions	4.17	0.19	.85	29.17	1.72	.09	16.67	0.88	.38
Amount of Conditions	20.83	0.92	.36	37.50	2.42	.02	37.50	2.42	.02
Method of Measurement	50.00	1.86	.06	16.67	0.47	.64	0.00	0.00	1.00
Number of Bugs	5.55	0.31	.76	-2.78	-0.12	.90	11.11	0.62	.54

Table 27
Iowa
Classroom Observations
Percent Time Spent by Teaching Style

Style	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 6		n = 3		n = 2		n = 3	
	freq.	%	freq.	%	freq.	%	freq.	%
Teacher Centered	5	9.26	8	12.50	2	11.11	9	34.62
Student & Teacher Centered	34	62.96	12	18.75	6	33.33	3	11.54
Student Centered	1	1.85	24	37.50	7	38.89	10	38.46
Administrative	6	11.11	8	12.50	2	11.11	3	11.54
Other activities	8	14.81	12	18.75	1	5.56	1	3.85

Statistical Tests

Style	1995 vs. 1996		1995 vs. 1997		1995 vs. 1998	
	X^2	p	X^2	p	X^2	p
Teacher Centered						
Student & Teacher Centered						
Student Centered						
Administrative						
Other activities						
	32.60	<.01	19.73	<.01	34.84	<.01

Table 28
Iowa
Learning Environment Inventory
Student Means

Subscale	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 111		n = 155		n = 143		n = 151	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Difficulty	3.09	0.08	2.92	0.07	2.90	0.07	2.67	0.06
Relevance	3.35	0.06	3.29	0.06	3.82	0.06	3.69	0.05
Critical Voice	3.16	0.08	3.18	0.09	3.83	0.09	3.54	0.06
Involvement	3.69	0.06	3.54	0.06	4.00	0.06	3.85	0.05
Sequencing	2.61	0.07	2.91	0.06	2.76	0.06	2.66	0.06
Experimenting	2.11	0.06	2.34	0.05	2.76	0.05	2.60	0.06

1 = Almost Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Almost Always

Statistical Tests

Subscale	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Difficulty	-0.17	1.45	.15	-0.19	1.88	.06	-0.42	4.10	<.01
Relevance	-0.06	0.59	.56	0.47	-5.46	<.01	0.34	-4.07	<.01
Critical Voice	0.02	-0.22	.82	0.67	-6.71	<.01	0.38	-3.93	<.01
Involvement	-0.15	1.64	.10	0.31	-3.76	<.01	0.16	-1.97	.05
Sequencing	0.30	-3.13	<.01	0.15	-1.55	.12	0.05	-0.54	.59
Experimenting	0.23	-2.84	<.01	0.65	-7.83	<.01	0.49	-6.00	<.01

Table 29
Iowa
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 106		n = 151		n = 137		n = 147	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Work in groups	2.26	0.06	4.50	0.05	4.58	0.05	4.11	0.06
Do experiments with other students	2.04	0.04	4.12	0.06	4.31	0.07	3.96	0.07
Ask students to suggest hypotheses	2.68	0.12	3.17	0.10	3.85	0.10	3.44	0.09
Share results from experiments	2.28	0.08	3.62	0.08	3.98	0.09	3.76	0.08
Ask for reasons for the results of experiments	2.81	0.11	3.85	0.08	4.34	0.06	4.15	0.07
Ask students to interpret data	3.06	0.12	3.58	0.10	4.02	0.08	3.84	0.08

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Work in groups	2.24	-28.60	<.01	2.32	-31.71	<.01	1.85	-20.44	<.01
Do experiments with other students	2.08	-25.48	<.01	2.27	-25.78	<.01	1.92	-21.00	<.01
Ask students to suggest hypotheses	0.49	-3.11	<.01	1.17	-7.69	<.01	0.76	-5.03	<.01
Share results from experiments	1.34	-11.67	<.01	1.70	-14.28	<.01	1.48	-13.02	<.01
Ask for reasons for the results of experiments	1.04	-7.80	<.01	1.53	-12.89	<.01	1.34	-11.17	<.01
Ask students to interpret data	0.52	-3.44	<.01	0.96	-6.81	<.01	0.78	-5.78	<.01

Table 30
Iowa
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 106		n = 151		n = 137		n = 147	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Work on projects	1.68	0.07	2.84	0.12	2.74	0.12	2.22	0.10
Read science textbook	3.45	0.12	1.76	0.07	2.32	0.11	2.30	0.10
Read articles on science	1.59	0.08	2.03	0.07	2.06	0.08	2.47	0.07
Do oral or written reports	1.16	0.04	1.31	0.05	2.10	0.10	1.56	0.07
Read other science materials	1.58	0.08	2.13	0.10	1.79	0.08	2.09	0.08

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Work on projects	1.16	-7.90	<.01	1.06	-7.20	<.01	0.54	-4.18	<.01
Read science textbook	-1.69	13.22	<.01	-1.13	6.94	<.01	-1.15	7.62	<.01
Read articles on science	0.44	-4.23	<.01	0.47	-4.14	<.01	0.88	-8.41	<.01
Do oral or written reports	0.15	-2.21	<.01	0.94	-8.03	<.01	0.40	-5.02	<.01
Read other science materials	0.55	-4.26	<.01	0.21	-1.95	.05	0.51	-4.38	<.01

Table 31
Iowa
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 106		n = 151		n = 137		n = 147	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Lecture	4.41	0.09	3.68	0.09	3.07	0.10	3.32	0.10
Demonstration of a scientific principle	3.34	0.10	3.53	0.08	3.88	0.08	3.53	0.07
Relate previous work to current topic	3.36	0.12	3.34	0.10	3.80	0.09	3.44	0.08
Go outside for class instruction	1.59	0.05	1.77	0.06	1.89	0.05	1.62	0.06
Watch films, slides, or videos	2.15	0.05	1.81	0.05	2.34	0.06	2.57	0.05

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Lecture	-0.73	5.64	<.01	-1.34	9.81	<.01	-1.09	7.85	<.01
Demonstration of a scientific principle	0.19	-1.47	.14	0.54	-4.33	<.01	0.19	-1.62	.11
Relate previous work to current topic	-0.02	0.19	.85	0.44	-3.03	<.01	0.08	-0.57	.57
Go outside for class instruction	0.18	-2.18	.03	0.30	-4.31	<.01	0.03	-0.27	.78
Watch films, slides. or videos	-0.34	4.71	<.01	0.19	-2.22	.03	0.42	-5.46	<.01

Table 32
Iowa
Student Questionnaire
Class Means
Percent of Students Who Have Participated in Science Activities Outside of Class

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 109		n = 154		n = 143		n = 151	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Talk about what you learn in science class	54.96	4.74	46.75	4.03	68.53	3.90	66.23	3.86
Watch a science program on TV	54.96	4.74	56.77	3.99	58.04	4.14	60.26	4.00
Go bird watching	18.92	3.73	12.90	2.70	11.19	2.65	16.56	3.03
Go to a science museum	50.91	4.79	50.32	4.03	42.66	4.15	43.05	4.04
Talk about science topics	34.23	4.52	40.65	3.96	55.24	4.17	43.05	4.04

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Talk about what you learn in science class	-8.21	-1.32	.19	13.57	2.21	.03	11.27	1.84	.07
Watch a science program on TV	1.81	0.29	.77	3.08	0.49	.62	5.30	0.85	.40
Go bird watching	-6.02	-1.31	.19	-7.73	-1.69	.09	-2.36	-0.49	.62
Go to a science museum	-0.59	-0.09	.93	-8.25	-1.30	.19	-7.86	-1.25	.21
Talk about science topics	6.42	1.07	.28	21.01	3.42	<.01	23.39	3.86	<.01

Table 32 - Iowa: Student Questionnaire
Percent of Students Who Have Participated in Science Activities Outside of Class (continued)

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 109		n = 154		n = 143		n = 151	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Build a telescope	1.80	1.27	3.23	1.42	2.80	1.38	2.65	1.31
Read books about science	19.09	3.76	17.42	3.06	27.97	3.77	23.18	3.45
Do a science experiment	33.33	4.49	43.23	3.99	39.86	4.11	32.45	3.82
Write an article for a science journal	0.00	0.00	5.16	1.78	1.40	0.99	1.99	1.14
Read a science magazine	35.16	4.55	29.68	3.68	27.27	3.74	28.48	3.68

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Build a telescope	1.43	0.75	.45	1.00	0.53	.60	0.85	0.47	.64
Read books about science	-1.67	-0.34	.73	8.88	1.67	.10	4.09	0.80	.44
Do a science experiment	9.90	1.65	.10	6.53	1.07	.28	-0.88	-0.15	.88
Write an article for a science journal	5.16	2.90	<.01	1.40	1.41	.16	1.99	1.75	.08
Read a science magazine	-5.48	-0.94	.35	-7.89	-1.34	.18	-6.68	-1.14	.25

Table 33
Iowa
Student Questionnaire
Class Means
Inclination to Continue Studying Science

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 103		n = 141		n = 138		n = 141	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Take a science class in 10th grade	98.20	1.27	99.35	0.65	100.00	0.00	99.34	0.66
Take a science class in 11th grade	83.49	3.57	85.06	2.88	90.14	2.51	96.03	5.22
Take a science class in 12th grade	38.68	4.75	54.97	4.06	65.71	4.03	68.71	3.84
Take a science class in college	65.74	4.59	55.26	4.05	67.39	4.01	79.05	6.08

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Take a science class in 10th grade	1.15	0.81	.42	1.80	1.42	.16	1.14	0.80	.42
Take a science class in 11th grade	1.57	0.34	.73	6.65	1.52	.13	12.54	1.98	.05
Take a science class in 12th grade	16.29	2.61	.01	27.03	4.34	<.01	30.03	4.92	<.01
Take a science class in college	-10.48	-1.71	.09	1.65	0.27	.79	13.31	1.75	.08

Table 34
Iowa
Student Questionnaire
Class Means
Science Motivation

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 103		n = 141		n = 138		n = 141	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Do you think you will pursue a career in science?	26.13	4.19	21.05	3.32	37.06	4.05	41.22	6.50
Have activities in science class made you want to take more science?	33.64	4.53	32.24	3.80	74.13	3.68	68.87	3.78
Is your science class motivating?	39.09	4.67	38.31	3.93	86.01	2.91	85.43	5.75
Have you ever had a "totally awesome" experience in your science class?	29.09	4.35	40.65	3.96	86.71	2.85	80.79	3.22

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Do you think you will pursue a career in science?	-5.08	-0.95	.34	10.93	1.88	.06	15.09	1.95	.05
Have activities in science class made you want to take more science?	-1.40	-0.24	.81	40.49	6.94	<.01	35.23	5.97	<.01
Is your science class motivating?	-0.78	-0.13	.90	46.92	8.53	<.01	46.34	6.26	<.01
Have you ever had a "totally awesome" experience in your science class?	11.56	1.97	.05	57.62	11.08	<.01	51.70	9.55	<.01

Table 35 - Iowa
Student Questionnaire - Class Means - Students' Attitudes toward Science

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 109		n = 155		n = 143		n = 151	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Science is useful to me outside of class.	3.28	0.11	3.32	0.10	3.82	0.09	3.65	0.09
The things you learn in science relate to the real world.	3.84	0.11	3.77	0.08	4.38	0.06	4.06	0.08
Much of what you learn in science classes will be useful in the future.	3.57	0.10	3.47	0.09	3.90	0.08	3.88	0.08
It is important to know some science in order to get a good job.	3.75	0.09	3.65	0.08	3.90	0.08	3.97	0.06
Science class is interesting.	2.73	0.12	2.59	0.09	3.97	0.08	3.73	0.08
Science class is fun.	2.78	0.11	2.81	0.09	4.01	0.08	3.80	0.07

1 = Strongly Disagree, 2 = Disagree, 3 = No Opinion, 4 = Agree, 5 = Strongly Agree

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Science is useful to me outside of class.	0.04	-0.23	.82	0.54	-3.81	<.01	0.37	-2.56	.01
The things you learn in science relate to the real world.	-0.07	0.47	.64	0.54	-4.74	<.01	0.22	-1.69	.10
Much of what you learn in science classes will be useful in the future.	-0.10	0.75	.45	0.33	-2.47	.01	0.31	-2.46	.02
It is important to know some science in order to get a good job.	-0.10	0.85	.40	0.15	-1.18	.24	0.22	-2.03	.04
Science class is interesting.	-0.14	0.92	.37	1.24	-8.98	<.01	1.00	-7.24	<.01
Science class is fun.	0.03	-0.18	.86	1.23	-9.35	<.01	1.02	-8.11	<.01

Table 36
Iowa
Science Literacy Test
Student Means
Percent Correct on Multiple Choice Items

Standard	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 151		n = 188		n = 185		n = 173	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	64.39	0.90	59.97	1.04	62.79	0.84	61.96	0.81
Science as Inquiry	69.05	1.37	62.33	1.31	67.13	1.23	68.26	1.18
Physical Science	67.83	1.41	60.59	1.47	60.90	1.37	64.02	1.29
Life Science	63.13	1.22	65.38	1.23	66.76	1.08	65.32	1.25
Earth & Space Sciences	58.28	1.43	50.27	1.39	53.33	1.17	50.00	1.24
Science & Technology	52.07	1.31	51.06	1.22	54.93	1.34	51.30	1.29
Science in Personal & Social Perspectives	65.23	1.65	59.71	1.80	64.10	1.38	62.52	1.35
History & Nature of Science	70.86	1.19	67.18	1.27	69.52	1.09	68.70	1.07

Statistical Tests

Standard	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	-4.41	-3.21	<.01	-1.59	-1.29	.20	-2.43	-2.00	.05
Science as Inquiry	-6.82	-3.60	<.01	-1.93	-1.05	.29	-0.79	-0.44	.66
Physical Science	-7.23	-3.56	<.01	-6.92	-3.53	<.01	-3.81	-1.99	.05
Life Science	2.25	1.29	.20	3.62	2.22	.03	2.18	1.25	.21
Earth & Space Sciences	-8.01	-4.02	<.01	-4.94	-2.68	.01	-8.28	-4.38	<.01
Science & Technology	-1.01	-0.56	.58	2.86	1.53	.13	-0.77	-0.42	.67
Science in Personal & Social Perspectives	-5.52	-2.26	.02	-1.13	-0.53	.60	-2.71	-1.27	.20
History & Nature of Science	-3.68	-2.12	.03	-1.34	-0.83	.41	-2.16	-1.35	.18

Table 37
Iowa
Lab Skills Performance Test
Student Means
Percent Correct by Total Score and Station

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 29		n = 27		n = 26		n = 30	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	70.05	2.20	74.37	2.23	72.49	2.98	75.92	2.45
Density	66.31	3.86	74.88	3.87	73.12	3.80	69.17	4.00
Sugar & Starch Indicators	62.55	5.35	66.29	4.59	67.56	5.60	73.92	4.04
Microscope	78.16	4.31	87.65	3.60	89.10	3.16	94.44	2.01
Rock Identification	80.84	2.95	82.10	3.58	68.16	4.64	85.19	3.92
Instruments	66.90	2.99	68.89	3.65	81.54	3.12	66.22	3.44

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	4.32	1.38	.17	2.44	0.66	.51	5.86	1.78	.08
Density	8.58	1.57	.12	6.81	1.26	.21	2.86	0.51	.61
Sugar & Starch Indicators	3.74	0.53	.60	5.01	0.65	.52	11.37	1.70	.09
Microscope	9.49	1.69	.09	10.94	2.05	.04	16.28	0.79	.43
Rock Identification	1.26	0.27	.79	-12.68	-2.30	.02	7.34	0.88	.38
Instruments	1.99	0.42	.67	14.64	3.39	<.01	-0.67	-0.15	.88

Table 38
Iowa
Hands On Full Investigation
Student Means
Percent Correct by Total Score and Station

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 6		n = 6		n = 6		n = 6	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	67.78	12.13	68.44	7.35	80.33	6.24	85.44	5.05
Number of Conditions	83.33	16.67	70.00	13.42	93.33	6.67	96.67	3.33
Access to Conditions	70.83	16.35	66.67	10.54	75.00	6.46	79.17	10.03
Amount of Conditions	54.17	17.56	66.67	8.33	83.33	5.27	87.50	5.59
Method of Measurement	75.00	11.18	66.67	10.54	83.33	10.54	75.00	17.08
Number of Bugs	55.56	14.05	72.22	10.24	66.67	12.17	88.89	7.03

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	0.66	0.05	.96	12.55	0.92	.36	17.66	1.34	.18
Number of Conditions	-13.33	-0.62	.54	10.00	0.56	.58	13.34	0.78	.44
Access to Conditions	-4.16	-0.21	.83	4.17	0.24	.81	8.34	0.43	.67
Amount of Conditions	12.50	0.64	.52	29.16	1.59	.11	33.33	1.81	.70
Method of Measurement	-8.33	-0.54	.59	8.33	0.54	.59	0.00	0.00	1.00
Number of Bugs	16.66	0.96	.34	11.11	0.60	.55	33.33	2.12	.03

Table 39
Iowa
Written Full Investigation
Student Means
Percent Correct by Total Score and Subscores

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 5		n = 5		n = 6		n = 5	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	75.00	19.36	80.27	5.82	70.72	7.48	88.33	4.86
Number of Conditions	80.00	20.00	88.00	8.00	80.00	10.33	100.00	0.00
Access to Conditions	75.00	19.36	70.00	9.35	54.17	4.17	75.00	7.91
Amount of Conditions	80.00	20.00	100.00	0.00	91.67	8.33	100.00	0.00
Method of Measurement	60.00	24.49	70.00	20.00	66.67	16.67	80.00	12.25
Number of Bugs	80.00	20.00	73.33	12.44	61.11	5.56	86.67	13.33

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	5.27	0.26	.79	-4.28	-0.21	.83	13.33	0.67	.50
Number of Conditions	8.00	0.37	.71	0.00	0.00	1.00	20.00	1.00	.32
Access to Conditions	-5.00	-0.23	.82	-20.83	-1.05	.29	0.00	0.00	1.00
Amount of Conditions	20.00	1.00	.32	11.67	0.54	.59	20.00	1.00	.32
Method of Measurement	10.00	0.32	.75	6.67	0.23	.82	20.00	0.73	.47
Number of Bugs	-6.67	-0.28	.78	-18.89	-0.91	.36	6.67	0.28	.78

Table 40
California
Classroom Observations
Percent Time Spent by Teaching Style

Style	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 9		n = 8		n = 3		n = 8	
	freq.	%	freq.	%	freq.	%	freq.	%
Teacher Centered	21	22.58	33	41.77	7	21.88	8	10.00
Student & Teacher Centered	26	27.96	24	30.38	10	31.25	13	16.25
Student Centered	24	25.81	3	3.80	10	31.25	39	48.75
Administrative	15	16.13	11	13.92	5	15.63	10	12.50
Other activities	7	7.53	8	10.13	0	0.00	10	12.50

Statistical Tests

Style	1995 vs. 1996		1995 vs. 1997		1995 vs. 1998	
	X^2	p	X^2	p	X^2	p
Teacher Centered						
Student & Teacher Centered						
Student Centered						
Administrative						
Other activities						
	18.73	<.01	2.78	7.05	14.33	<.01

Table 41
California
Learning Environment Inventory
Student Means

Subscale	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 298		n = 351		n = 322		n = 415	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Difficulty	2.99	.04	2.79	.04	2.82	0.04	2.75	0.04
Relevance	3.38	.04	3.42	.04	3.24	0.04	3.32	0.04
Critical Voice	3.61	.05	3.67	.04	3.53	0.05	3.60	0.04
Involvement	3.55	.04	3.63	.04	3.56	0.04	3.55	0.04
Sequencing	2.53	.05	2.68	.05	2.89	0.05	2.73	0.04
Experimenting	2.47	.04	2.65	.04	2.68	0.04	2.65	0.04

1 = Almost Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Almost Always

Statistical Tests

Subscale	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Difficulty	-0.20	3.43	<.01	-0.17	2.86	<.01	-0.24	4.25	<.01
Relevance	0.04	-0.74	.46	-0.09	1.42	.16	-0.26	0.96	.34
Critical Voice	0.06	-0.90	.37	-0.08	1.32	.19	-0.01	0.14	.89
Involvement	0.08	-1.43	.15	0.01	-0.27	.79	0.00	0.08	.94
Sequencing	0.15	-2.15	.03	0.36	-5.04	<.01	0.20	-2.93	<.01
Experimenting	0.18	-3.20	.00	0.21	-3.51	<.01	0.18	-3.02	<.01

Table 42
California
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 276		n = 324		n = 303		n = 382	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Work in groups	3.07	0.07	4.69	0.04	4.78	0.04	4.70	0.05
Do experiments with other students	2.91	0.06	4.31	0.06	4.44	0.06	4.09	0.07
Ask students to suggest hypotheses	3.23	0.07	3.48	0.07	3.25	0.08	3.41	0.06
Share results from experiments	2.93	0.07	3.52	0.06	3.56	0.08	3.53	0.07
Ask for reasons for the results of experiments	3.39	0.07	3.94	0.06	4.03	0.07	3.71	0.07
Ask students to interpret data	2.94	0.07	3.63	0.07	3.67	0.07	3.49	0.07

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5=Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Work in groups	1.62	-12.46	<.01	1.71	-13.27	<.01	1.63	-12.42	<.01
Do experiments with other students	1.40	-16.25	<.01	1.53	-16.86	<.01	1.18	-12.08	<.01
Ask students to suggest hypotheses	0.25	-2.49	.01	0.02	-0.15	.88	0.18	-1.79	.07
Share results from experiments	0.59	-6.18	.01	0.63	-6.06	<.01	0.60	-6.10	<.01
Ask for reasons for the results of experiments	0.55	-5.93	<.01	0.64	-6.50	<.01	0.32	-3.26	<.01
Ask students to interpret data	0.69	-6.78	<.01	0.73	-7.15	<.01	0.55	-5.29	<.01

Table 43
California
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 276		n = 324		n = 303		n = 382	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Work on projects	2.87	0.07	3.65	0.07	3.40	0.08	3.22	0.07
Read science textbook	3.19	0.07	1.73	0.05	2.10	0.05	2.45	0.05
Read articles on science	1.87	0.06	2.52	0.06	2.04	0.06	2.06	0.05
Do oral or written reports	1.59	0.05	1.99	0.06	1.95	0.06	1.76	0.05
Read other science materials	2.32	0.08	2.64	0.07	2.58	0.08	2.48	0.06

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Work on projects	0.78	7.59	<.01	0.53	-5.09	<.01	0.35	-3.41	<.01
Read science textbook	-1.46	16.51	<.01	-1.09	12.58	<.01	-0.74	8.66	<.01
Read articles on science	0.65	-7.73	<.01	0.17	-1.92	.06	0.19	-2.28	.02
Do oral or written reports	0.40	-5.16	<.01	0.36	-4.39	<.01	0.17	-2.39	.02
Read other science materials	0.32	-3.00	<.01	0.26	-2.32	.02	0.16	-1.52	.13

Table 44
California
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 276		n = 324		n = 303		n = 382	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Lecture	3.54	0.08	3.53	0.08	3.59	0.08	3.67	0.07
Demonstration of a scientific principle	3.34	0.07	3.59	0.06	3.45	0.07	3.43	0.06
Relate previous work to current topic	3.14	0.08	3.63	0.06	3.58	0.07	3.38	0.07
Go outside for class instruction	1.67	0.05	2.12	0.05	1.67	0.05	1.81	0.05
Watch films, slides. or videos	3.07	0.05	2.92	0.05	3.07	5.24	2.66	0.05

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Lecture	-0.01	.08	.93	0.05	-0.46	.65	0.13	-1.19	.24
Demonstration of a scientific principle	0.25	-2.67	.01	0.11	-1.10	.27	0.09	-0.89	.37
Relate previous work to current topic	0.49	-5.02	<.01	0.44	-4.31	<.01	0.24	-2.28	.02
Go outside for class instruction	0.45	-6.17	<.01	0.00	-8.63	<.01	0.14	-1.86	.06
Watch films, slides. or videos	-0.15	2.05	.04	0.00	3.69	<.01	-0.41	5.43	<.01

Table 45
California
Student Questionnaire
Class Means
Percent of Students Who Have Participated in Science Activities Outside of Class

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 282		n = 338		n = 317		n = 411	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Talk about what you learn in science class	56.76	2.88	60.00	2.64	56.11	3.90	50.36	2.46
Watch a science program on TV	63.01	2.83	63.29	2.60	61.88	2.72	61.35	3.51
Go bird watching	10.54	1.79	13.91	1.87	15.05	2.00	13.77	1.70
Go to a science museum	35.02	2.77	36.02	2.58	25.94	2.45	24.64	3.32
Talk about science topics	47.44	2.99	52.89	2.69	48.75	2.80	47.58	3.05

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Talk about what you learn in science class	3.24	0.83	.41	-0.65	-0.13	.90	-6.40	-1.69	.09
Watch a science program on TV	0.28	0.07	.94	-1.13	-0.29	.77	-1.66	-0.37	.71
Go bird watching	3.37	1.30	.19	4.51	1.68	.09	3.23	1.31	.19
Go to a science museum	1.00	0.26	.79	-9.08	-2.46	.01	-10.38	-2.40	.02
Talk about science topics	5.45	1.36	.17	1.31	0.32	.75	0.14	0.03	.98

Table 45 – California: Student Questionnaire
Percent of Students Who Have Participated in Science Activities Outside of Class (continued)

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 282		n = 338		n = 317		n = 411	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Build a telescope	7.12	1.50	6.05	1.28	4.38	1.15	9.22	2.31
Read books about science	47.78	2.92	43.64	2.67	40.44	2.75	39.37	3.01
Do a science experiment	52.72	2.92	54.47	2.57	45.63	2.79	49.88	3.56
Write an article for a science journal	9.49	1.71	35.26	2.57	21.56	4.03	16.71	1.84
Read a science magazine	42.86	2.89	48.42	2.69	38.44	3.59	35.27	2.35

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Build a telescope	-1.07	-0.54	.59	-2.74	-1.45	.15	2.10	0.76	.45
Read books about science	-4.14	-1.05	.29	-7.34	-1.83	.07	-8.41	-2.01	.04
Do a science experiment	1.75	0.44	.66	-7.09	-1.76	.08	-2.84	-0.62	.54
Write an article for a science journal	25.77	8.35	<.01	12.07	2.76	.01	7.22	2.87	<.01
Read a science magazine	5.56	1.41	.16	-4.42	-0.96	.34	-7.59	-2.04	.04

Table 46
California
Student Questionnaire
Class Means
Inclination to Continue Studying Science

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 241		n = 293		n = 289		n = 372	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Take a science class in 10th grade	92.83	1.51	94.51	1.23	97.80	0.82	94.09	1.17
Take a science class in 11th grade	75.52	2.55	75.60	2.35	78.59	3.34	77.17	3.36
Take a science class in 12th grade	55.20	2.98	54.05	2.74	59.61	4.45	56.11	3.11
Take a science class in college	66.43	2.81	61.66	2.70	70.16	4.36	65.05	3.08

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Take a science class in 10th grade	1.68	0.86	.39	4.97	2.89	<.01	1.26	0.66	.51
Take a science class in 11th grade	0.08	0.02	.98	3.07	0.73	.47	1.65	0.39	.70
Take a science class in 12th grade	-1.15	-0.28	.78	4.41	0.82	.41	0.91	0.21	.83
Take a science class in college	-4.77	-1.22	.22	3.73	0.72	.47	-1.38	-0.33	.74

Table 47
California
Student Questionnaire
Class Means
Science Motivation

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 241		n = 293		n = 289		n = 372	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Do you think you will pursue a career in science?	28.93	2.71	26.65	2.42	40.63	4.36	30.71	3.47
Have activities in science class made you want to take more science?	46.10	2.97	47.51	2.71	48.28	5.95	43.41	4.76
Is your science class motivating?	54.87	3.00	61.63	2.68	57.37	6.06	59.12	5.08
Have you ever had a "totally awesome" experience in your science class?	43.45	2.92	48.26	2.70	37.19	2.71	49.63	4.42

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Do you think you will pursue a career in science?	-2.28	-0.63	.53	11.70	2.28	.02	1.78	0.40	.69
Have activities in science class made you want to take more science?	1.41	0.35	.73	2.18	0.33	.74	-2.69	-0.48	.63
Is your science class motivating?	6.76	1.68	.09	2.50	0.37	.71	4.25	0.72	.47
Have you ever had a "totally awesome" experience in your science class?	4.81	1.21	.23	-6.26	-1.57	.12	6.18	1.17	.24

Table 48 - California
Student Questionnaire - Class Means - Students' Attitudes toward Science

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 289		n = 340		n = 319		n = 406	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Science is useful to me outside of class.	3.18	0.07	3.33	0.07	3.25	0.07	3.08	0.06
The things you learn in science relate to the real world.	3.77	0.07	3.72	0.07	3.81	0.06	3.70	0.06
Much of what you learn in science classes will be useful in the future.	3.75	0.07	3.78	0.06	3.66	0.06	3.73	0.05
It is important to know some science in order to get a good job.	3.68	0.06	3.69	0.05	3.72	0.05	3.70	0.05
Science class is interesting.	3.01	0.07	3.09	0.07	2.83	0.07	2.84	0.07
Science class is fun.	3.21	0.07	3.19	0.06	2.93	0.07	2.97	0.06

1 = Strongly Disagree, 2 = Disagree, 3 = No Opinion, 4 = Agree, 5 = Strongly Agree

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Science is useful to me outside of class.	0.15	-1.60	.11	0.07	-0.75	.45	-0.10	1.06	.29
The things you learn in science relate to the real world.	-0.05	0.53	.60	0.04	-0.38	.70	-0.07	0.71	.48
Much of what you learn in science classes will be useful in the future.	0.03	-0.43	.67	-0.09	0.90	.37	-0.02	0.14	.89
It is important to know some science in order to get a good job.	0.01	-0.08	.94	0.04	-0.41	.68	0.02	-0.22	.83
Science class is interesting.	0.08	-0.74	.46	-0.18	1.88	.06	-0.17	1.74	.08
Science class is fun.	-0.02	0.18	.86	-0.28	2.96	<.01	-0.24	2.59	.01

Table 49
California
Science Literacy Test
Student Means
Percent Correct on Multiple Choice Items

Standard	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 324		n = 329		n = 360		n = 299	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	47.12	0.81	47.56	.88	50.14	0.77	50.12	0.83
Science as Inquiry	50.59	1.21	49.24	1.13	54.32	1.18	52.60	1.16
Physical Science	43.06	1.19	42.56	1.03	46.85	1.14	47.69	1.47
Life Science	46.60	1.02	47.94	1.16	50.95	1.06	53.09	1.10
Earth & Space Sciences	38.79	1.05	41.08	1.05	42.59	0.97	41.08	1.07
Science & Technology	48.15	0.97	48.52	0.98	48.89	0.86	48.08	0.93
Science in Personal & Social Perspectives	41.74	1.33	42.68	1.26	43.66	1.06	45.18	1.25
History & Nature of Science	60.42	0.92	60.77	0.96	62.63	0.92	61.69	0.97

Statistical Tests

Standard	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	0.44	0.37	.71	3.02	2.70	.01	3.00	2.59	.01
Science as Inquiry	-1.35	-0.82	.41	3.73	2.21	.03	2.01	1.20	.23
Physical Science	-0.50	-0.32	.75	3.80	2.30	.02	4.63	2.45	.01
Life Science	1.34	0.87	.38	4.34	2.95	<.01	4.49	4.32	<.01
Earth & Space Sciences	2.30	1.55	.12	3.81	2.67	.01	2.30	1.54	.12
Science & Technology	0.37	0.27	.79	0.74	0.57	.57	-0.07	-0.05	.96
Science in Personal & Social Perspectives	0.94	0.51	.61	1.91	1.12	.26	3.43	1.88	.06
History & Nature of Science	0.34	0.26	.79	2.21	1.69	.09	1.27	0.95	.34

Table 50
California
Lab Skills Performance Test
Student Means
Percent Correct by Total Score and Station

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 26		n = 25		n = 16		n = 27	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	66.40	2.87	61.30	2.94	53.38	5.24	63.90	2.99
Density	53.41	4.90	47.54	4.77	58.14	7.56	50.81	5.26
Sugar & Starch Indicators	68.63	3.99	58.11	5.12	39.58	8.13	54.08	4.88
Microscope	65.06	5.74	75.00	6.16	44.79	4.29	78.70	3.91
Rock Identification	73.18	4.83	74.11	4.33	65.28	5.73	79.01	3.35
Instruments	71.54	3.28	60.53	3.81	65.83	4.12	69.38	3.72

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	-5.10	-1.24	.22	-11.02	-1.85	.06	-2.51	-0.61	.54
Density	-5.86	-0.86	.39	4.73	0.53	.60	-2.60	-0.36	.72
Sugar & Starch Indicators	-10.51	-1.62	.11	-29.04	-3.21	<.01	-14.54	-2.31	.02
Microscope	9.94	1.18	.24	-20.27	-2.83	<.01	13.64	1.96	.05
Rock Identification	0.93	0.14	.89	-7.91	-1.05	.29	5.83	0.99	.32
Instruments	-11.01	-2.19	.03	-5.71	-1.08	.28	-2.16	-0.43	.67

Table 51
California
Hands On Full Investigation
Student Means
Percent Correct by Total Score and Station

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 6		n = 6		n = 6		n = 6	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	62.00	9.65	73.67	7.98	90.17	2.85	56.72	13.06
Number of Conditions	60.00	13.66	76.67	16.67	96.67	3.33	60.00	17.89
Access to Conditions	45.83	13.57	62.50	14.07	87.50	5.59	54.17	15.02
Amount of Conditions	70.83	13.57	87.50	5.59	83.33	5.27	50.00	15.81
Method of Measurement	66.67	10.54	75.00	17.08	100.00	0.00	58.33	15.37
Number of Bugs	66.67	8.61	66.67	8.61	83.33	7.45	61.11	10.24

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	11.67	0.93	.35	28.17	2.80	.02	-5.28	-0.33	.74
Number of Conditions	16.67	0.77	.44	36.67	2.61	.01	0.00	0.00	1.00
Access to Conditions	16.67	0.85	.40	41.67	2.84	<.01	8.34	0.41	.68
Amount of Conditions	16.67	1.14	.25	12.50	0.86	.39	-20.83	-1.00	.32
Method of Measurement	8.33	0.42	.67	33.33	3.16	<.01	-8.34	-0.45	.65
Number of Bugs	0.00	0.00	1.00	16.66	1.46	.14	-5.56	-0.42	.67

Table 52
California
Written Full Investigation
Student Means
Percent Correct by Total Score and Subscores

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 6		n = 6		n = 6		n = 2	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	78.11	3.48	31.61	15.82	66.11	5.19	28.00	20.00
Number of Conditions	93.33	6.67	23.33	15.85	66.67	11.16	40.00	0.00
Access to Conditions	58.33	5.27	25.00	15.81	58.33	5.27	25.00	25.00
Amount of Conditions	100.00	0.00	20.83	16.35	75.00	9.13	25.00	25.00
Method of Measurement	66.67	10.54	33.33	16.67	58.33	15.37	0.00	0.00
Number of Bugs	72.22	10.24	55.56	20.49	72.22	5.56	50.00	50.00

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	-46.50	-2.87	<.01	-12.00	-1.92	.05	-50.11	-2.47	.01
Number of Conditions	-70.00	-4.07	<.01	-26.66	-2.05	.04	-53.33	-8.00	<.01
Access to Conditions	-33.33	-2.00	.05	0.00	0.00	1.00	-33.33	-1.30	.19
Amount of Conditions	-79.17	-4.84	<.01	-25.00	-2.74	.01	-75.00	-3.00	<.01
Method of Measurement	-33.34	-1.69	.09	-8.34	-0.45	.65	-66.67	-6.33	<.01
Number of Bugs	-16.66	-0.73	.47	0.00	0.00	1.00	-22.22	-0.44	.66

Table 53
Texas
Classroom Observations
Percent Time Spent by Teaching Style

Style	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 7		n = 7		n = 3		n = 8	
	freq.	%	freq.	%	freq.	%	freq.	%
Teacher Centered	63	77.78	18	24.32	5	17.86	36	61.02
Student & Teacher Centered	4	4.94	9	12.16	12	42.86	20	33.90
Student Centered	6	7.41	28	37.84	11	39.29	0	0.00
Administrative	6	7.41	14	18.92	0	0.00	3	5.08
Other activities	2	2.47	5	6.76	0	0.00	0	0.00

Statistical Tests

Style	1995 vs. 1996		1995 vs. 1997		1995 vs. 1998	
	X^2	p	X^2	p	X^2	p
Teacher Centered						
Student & Teacher Centered						
Student Centered						
Administrative						
Other activities						
	45.74	<.01	48.51	<.01	24.01	<.01

Table 54
Texas
Learning Environment Inventory
Student Means

Subscale	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 215		n = 245		n = 222		n = 165	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Difficulty	2.77	0.05	2.69	0.04	2.77	0.04	2.66	0.05
Relevance	3.25	0.05	3.38	0.04	3.49	0.05	3.51	0.05
Critical Voice	3.64	0.05	3.77	0.04	3.71	0.05	3.80	0.05
Involvement	3.41	0.05	3.68	0.04	3.68	0.05	3.64	0.05
Sequencing	2.46	0.06	2.20	0.05	2.17	0.05	2.31	0.07
Experimenting	2.28	0.05	2.61	0.05	2.51	0.06	2.56	0.06

1 = Almost Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Almost Always

Statistical Tests

Subscale	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Difficulty	-0.08	1.30	.19	0.00	-0.10	.92	-0.11	1.55	.12
Relevance	0.13	-2.02	.04	0.24	-3.69	<.01	0.26	-3.69	<.01
Critical Voice	0.13	-1.91	.06	0.07	-1.02	.31	0.16	-2.18	.03
Involvement	0.27	-4.09	<.01	0.27	-4.12	<.01	0.23	-3.25	<.01
Sequencing	-0.26	3.26	<.01	-0.29	3.56	<.01	-0.15	1.64	.10
Experimenting	0.33	-4.45	<.01	0.23	-2.98	<.01	0.28	-3.39	<.01

Table 55
Texas
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 205		n = 203		n = 195		n = 156	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Work in groups	2.83	0.10	3.76	0.09	3.90	0.09	3.47	0.11
Do experiments with other students	2.38	0.08	3.33	0.09	3.25	0.09	2.56	0.09
Ask students to suggest hypotheses	2.72	0.10	3.10	0.09	3.33	0.10	3.05	0.11
Share results from experiments	2.53	0.09	3.42	0.09	3.42	0.09	3.12	0.11
Ask for reasons for the results of experiments	2.79	0.09	3.44	0.09	3.58	0.09	3.30	0.11
Ask students to interpret data	2.79	0.09	3.39	0.09	3.33	0.10	3.08	0.11

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Work in groups	0.93	-6.96	<.01	1.07	-8.15	<.01	0.64	-4.41	<.01
Do experiments with other students	0.95	-8.13	<.01	0.87	-7.50	<.01	0.18	-1.50	.14
Ask students to suggest hypotheses	0.38	-2.84	<.01	0.61	-4.31	<.01	0.33	-2.26	.03
Share results from experiments	0.89	-6.79	.01	0.89	-7.03	<.01	0.59	-4.27	<.01
Ask for reasons for the results of experiments	0.65	-4.21	<.01	0.79	-5.15	<.01	0.51	-2.89	<.01
Ask students to interpret data	0.60	-4.58	<.01	0.54	-3.97	<.01	0.29	-1.99	.05

Table 56
Texas
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 205		n = 203		n = 195		n = 156	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Work on projects	2.06	0.07	2.94	0.10	3.05	0.10	2.83	0.11
Read science textbook	3.32	0.09	2.80	0.09	2.97	0.10	3.16	0.11
Read articles on science	1.98	0.08	2.11	0.08	2.24	0.09	2.14	0.09
Do oral or written reports	1.71	0.07	2.20	0.09	2.22	0.09	1.87	0.09
Read other science materials	2.21	0.09	2.68	0.09	2.63	0.10	2.45	0.11

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Work on projects	0.88	-7.18	<.01	0.99	-8.07	<.01	0.77	-6.09	<.01
Read science textbook	-0.52	4.06	<.01	-0.35	2.72	.01	-0.16	1.20	.23
Read articles on science	0.13	-1.14	.26	0.26	-2.19	.03	0.16	-1.36	.18
Do oral or written reports	0.49	-4.39	<.01	0.51	-4.44	<.01	0.16	-1.35	.18
Read other science materials	0.47	-3.66	<.01	0.42	-3.12	<.01	0.24	-1.70	.09

Table 57
Texas
Student Questionnaire
Class Means
Frequency of Class Activities in SS&C and Comparison Classes

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 205		n = 203		n = 195		n = 156	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Lecture	3.42	0.11	3.39	0.10	3.62	0.10	3.58	0.12
Demonstration of a scientific principle	3.06	0.09	3.38	0.09	3.49	0.09	3.41	0.10
Relate previous work to current topic	3.19	0.09	3.38	0.09	3.50	0.10	3.30	0.11
Go outside for class instruction	1.48	0.07	1.93	0.08	1.83	0.09	1.70	0.08
Watch films, slides. or videos	2.54	0.07	2.97	0.08	2.49	0.08	2.25	0.10

1 = Never, 2 = Less than once a week, 3 = About once a week, 4 = Several times a week, 5 = Almost every day

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Lecture	-0.03	0.16	.88	0.20	-1.35	.18	0.16	-1.02	.31
Demonstration of a scientific principle	0.32	-2.59	.01	0.43	-3.35	<.01	0.35	-2.57	.01
Relate previous work to current topic	0.19	-1.53	.13	0.31	-2.38	.02	0.11	-0.80	.43
Go outside for class instruction	0.45	-4.32	<.01	0.35	-3.32	<.01	0.22	-2.14	.03
Watch films, slides. or videos	0.43	-4.32	<.01	-0.05	0.54	.59	-0.29	2.56	.01

Table 58
Texas
Student Questionnaire
Class Means
Percent of Students Who Have Participated in Science Activities Outside of Class

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 206		n = 235		n = 207		n = 161	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Talk about what you learn in science class	37.74	3.34	56.67	3.21	53.08	3.44	44.17	3.90
Watch a science program on TV	47.17	3.44	57.50	3.20	61.43	4.91	60.74	3.84
Go bird watching	8.49	1.92	14.58	2.28	15.17	4.33	14.72	2.78
Go to a science museum	44.86	3.41	48.12	3.24	49.05	3.46	49.69	3.93
Talk about science topics	28.64	3.10	41.25	3.18	45.45	3.75	42.33	3.88

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Talk about what you learn in science class	18.93	4.09	<.01	15.34	3.20	<.01	6.43	1.25	.21
Watch a science program on TV	10.33	2.20	.03	-15.74	-2.63	.01	13.57	2.63	.16
Go bird watching	6.09	2.04	.04	6.68	1.41	.16	6.23	1.84	.07
Go to a science museum	3.26	0.69	.49	4.19	0.86	.39	4.83	0.93	.35
Talk about science topics	12.61	2.84	<.01	16.81	3.45	<.01	13.69	2.76	.01

Table 58 – Texas: Student Questionnaire
Percent of Students Who Have Participated in Science Activities Outside of Class (continued)

Activity	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 206		n = 235		n = 207		n = 161	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Build a telescope	5.63	1.58	5.00	1.41	6.19	1.67	5.52	1.79
Read books about science	44.60	3.41	51.46	3.24	46.67	3.45	45.06	3.92
Do a science experiment	39.81	3.38	63.18	3.13	59.05	3.40	57.41	3.90
Write an article for a science journal	7.55	1.82	13.81	3.24	12.86	4.26	7.98	2.13
Read a science magazine	41.31	3.38	38.91	3.16	39.52	3.38	46.01	3.92

Statistical Tests

Activity	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Build a telescope	-0.63	-0.30	.76	0.56	0.24	.81	-0.11	-0.05	.96
Read books about science	6.86	1.46	.14	2.07	0.43	.67	0.46	0.09	.93
Do a science experiment	23.37	5.07	<.01	19.24	4.01	<.01	17.60	3.41	<.01
Write an article for a science journal	6.26	2.17	.03	5.31	1.15	.25	0.43	0.15	.88
Read a science magazine	-2.40	-0.52	.60	-1.79	-0.37	.71	4.70	0.91	.36

Table 59
Texas
Student Questionnaire
Class Means
Inclination to Continue Studying Science

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 194		n = 211		n = 178		n = 150	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Take a science class in 10th grade	89.47	2.13	93.72	1.57	96.12	1.35	65.60	1.63
Take a science class in 11th grade	82.69	2.63	87.01	2.22	84.73	2.53	87.50	2.62
Take a science class in 12th grade	62.50	3.36	65.22	3.15	66.33	3.38	80.00	3.17
Take a science class in college	61.17	3.40	69.00	3.06	68.56	3.34	63.52	3.83

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Take a science class in 10th grade	4.25	1.61	.11	6.65	2.64	.01	6.13	2.29	.02
Take a science class in 11th grade	4.32	1.26	.21	2.04	0.56	.58	4.81	1.30	.19
Take a science class in 12th grade	2.72	0.59	.46	3.83	0.80	.42	17.50	3.79	<.01
Take a science class in college	7.83	1.71	.09	7.39	1.55	.12	2.35	0.46	.65

Table 60
Texas
Student Questionnaire
Class Means
Science Motivation

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 194		n = 211		n = 178		n = 150	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Do you think you will pursue a career in science?	22.38	2.88	32.07	3.04	33.99	4.98	23.13	3.34
Have activities in science class made you want to take more science?	30.00	3.17	53.62	3.26	51.69	3.48	38.89	3.84
Is your science class motivating?	47.60	3.47	65.37	3.14	66.34	3.33	59.75	3.90
Have you ever had a "totally awesome" experience in your science class?	40.76	3.39	70.64	2.98	64.25	3.34	59.88	3.86

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Do you think you will pursue a career in science?	9.69	2.31	.02	11.61	2.02	.04	0.75	0.17	.87
Have activities in science class made you want to take more science?	23.62	5.19	<.01	21.69	4.61	<.01	8.89	1.79	.07
Is your science class motivating?	17.77	3.80	<.01	18.74	3.90	<.01	12.15	2.33	.02
Have you ever had a "totally awesome" experience in your science class?	29.88	6.62	<.01	23.49	4.99	<.01	19.12	3.72	<.01

Table 61 - Texas
Student Questionnaire - Class Means - Students' Attitudes toward Science

Item	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 210		n = 222		n = 203		n = 161	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Science is useful to me outside of class.	3.10	0.08	3.32	0.08	3.24	0.09	3.28	0.10
The things you learn in science relate to the real world.	3.58	0.08	3.59	0.08	3.81	0.08	3.88	0.09
Much of what you learn in science classes will be useful in the future.	3.74	0.08	3.96	0.07	3.96	0.08	3.98	0.08
It is important to know some science in order to get a good job.	3.44	0.08	3.62	0.07	3.57	0.08	3.56	0.09
Science class is interesting.	2.84	0.08	3.28	0.07	3.30	0.08	3.13	0.09
Science class is fun.	2.85	0.08	3.49	0.08	3.44	0.08	3.25	0.09

1 = Strongly Disagree, 2 = Disagree, 3 = No Opinion, 4 = Agree, 5 = Strongly Agree

Statistical Tests

Item	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	t	p	Δ	t	p	Δ	t	p
Science is useful to me outside of class.	0.22	-1.96	.05	0.14	-1.13	.26	0.18	-1.40	.16
The things you learn in science relate to the real world.	0.01	-0.15	.88	0.23	-2.01	.05	0.30	-2.52	.01
Much of what you learn in science classes will be useful in the future.	0.22	-2.17	.03	0.22	-1.93	.06	0.24	-2.10	.01
It is important to know some science in order to get a good job.	0.18	-1.75	.08	0.13	-1.19	.24	0.12	-0.97	.33
Science class is interesting.	0.44	-3.94	<.01	0.46	-3.98	<.01	0.29	-2.36	.02
Science class is fun.	0.64	-5.75	<.01	0.59	-5.24	<.01	0.40	-3.24	<.01

Table 62
Texas
Science Literacy Test
Student Means
Percent Correct on Multiple Choice Items

Standard	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 216		n = 156		n = 162		n = 142	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	42.22	0.75	44.00	1.13	37.08	0.80	42.54	0.98
Science as Inquiry	45.20	1.25	46.21	1.62	37.88	1.18	43.28	1.52
Physical Science	39.12	1.26	39.80	1.73	29.99	1.32	36.21	1.44
Life Science	40.20	1.02	42.15	1.38	36.47	1.37	43.13	1.59
Earth & Space Sciences	33.53	1.11	37.61	1.26	28.60	1.20	33.86	1.17
Science & Technology	47.28	1.08	47.12	1.42	48.46	1.11	47.98	1.39
Science in Personal & Social Perspectives	32.38	1.10	37.77	1.46	27.88	1.32	34.68	1.38
History & Nature of Science	58.16	1.11	57.45	1.38	52.80	1.38	59.10	1.34

Statistical Tests

Standard	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	1.78	1.31	.19	-5.15	-4.68	<.01	.31	0.25	.80
Science as Inquiry	1.01	0.49	.62	-7.32	-4.26	<.01	-1.92	-0.98	.33
Physical Science	0.68	0.32	.75	-9.13	-5.01	<.01	-2.91	-1.53	.13
Life Science	1.95	1.13	.26	-3.73	-2.18	.03	2.93	1.56	.12
Earth & Space Sciences	4.08	2.42	.02	-4.93	-3.00	<.01	0.34	0.21	.83
Science & Technology	-0.16	-0.09	.93	1.18	0.76	.45	0.70	0.39	.70
Science in Personal & Social Perspectives	5.39	2.95	<.01	-4.50	-2.62	.01	2.31	1.31	.19
History & Nature of Science	-0.71	-0.40	.69	-5.35	-3.02	.00	0.95	0.54	.59

Table 63
Texas
Lab Skills Performance Test
Student Means
Percent Correct by Total Score and Station

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 10		n = 16		n = 12		n = 28	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	40.61	3.18	50.47	3.30	42.93	5.31	50.20	3.19
Density	39.27	5.39	44.40	5.67	31.34	6.40	36.90	4.37
Sugar & Starch Indicators	29.63	6.70	37.09	5.26	40.43	7.28	45.24	4.64
Microscope	61.67	7.26	56.77	6.86	46.53	6.28	68.15	4.98
Rock Identification	41.39	7.54	63.72	6.21	52.55	8.54	62.70	5.69
Instruments	52.67	5.83	57.92	4.38	47.22	5.77	50.71	3.79

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	9.87	2.15	.03	3.32	0.38	.70	9.59	2.13	.03
Density	5.13	0.66	.51	-7.93	-0.95	.34	-2.36	-0.34	.73
Sugar & Starch Indicators	7.47	0.88	.38	10.80	1.09	.28	15.61	1.92	.05
Microscope	-4.90	-0.49	.62	-15.14	-1.58	.11	6.49	0.74	.46
Rock Identification	22.33	2.29	.02	11.16	0.98	.33	21.31	2.26	.02
Instruments	5.25	0.72	.47	-5.44	-0.66	.51	-1.95	-0.28	.78

Table 64
Texas
Hands On Full Investigation
Student Means
Percent Correct by Total Score and Station

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 6		n = 6		n = 6		n = 8	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	53.11	10.81	57.67	4.34	61.17	9.52	59.46	7.24
Number of Conditions	60.00	17.13	63.33	13.08	60.00	13.66	65.00	14.02
Access to Conditions	37.50	8.54	50.00	6.46	37.50	12.50	43.75	11.33
Amount of Conditions	54.17	20.83	50.00	12.91	66.67	21.08	59.38	15.63
Method of Measurement	58.33	8.33	58.33	8.33	58.33	8.33	50.00	9.45
Number of Bugs	55.56	16.48	66.67	8.61	83.33	7.45	79.17	6.10

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	4.56	0.39	.70	8.06	0.56	.58	6.35	0.49	.62
Number of Conditions	3.33	0.15	.88	0.00	0.00	1.00	5.00	0.23	.82
Access to Conditions	12.50	1.17	.24	0.00	0.00	1.00	6.25	0.44	.66
Amount of Conditions	-4.17	-0.17	.87	12.50	0.42	.67	5.21	0.20	.84
Method of Measurement	0.00	0.00	1.00	0.00	0.00	1.00	-8.33	-0.66	.51
Number of Bugs	11.11	0.60	.55	27.77	1.54	.12	23.61	1.34	.18

Table 65
Texas
Written Full Investigation
Student Means
Percent Correct by Total Score and Subscores

Station	Comparison (1995)		SS&C 1 (1996)		SS&C 2 (1997)		SS&C 3 (1998)	
	n = 2		n = 5		n = 4		n = 7	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Total Score	36.67	36.67	12.80	7.14	70.42	10.61	37.95	7.95
Number of Conditions	50.00	50.00	4.00	4.00	75.00	9.57	45.71	16.16
Access to Conditions	0.00	0.00	10.00	10.00	62.50	12.50	32.14	8.99
Amount of Conditions	50.00	50.00	0.00	0.00	93.75	6.25	35.71	15.29
Method of Measurement	50.00	50.00	30.00	20.00	37.50	23.94	42.86	13.04
Number of Bugs	33.33	33.33	20.00	13.33	83.33	13.33	33.33	10.29

Statistical Tests

Station	1995 vs. 1996			1995 vs. 1997			1995 vs. 1998		
	Δ	z	p	Δ	z	p	Δ	z	p
Total Score	-23.87	-0.64	.52	33.75	0.88	.38	1.28	0.03	.98
Number of Conditions	-46.00	-0.92	.36	25.00	0.49	.62	-4.29	-0.08	.94
Access to Conditions	10.00	1.00	.32	62.50	5.00	<.01	32.14	3.58	<.01
Amount of Conditions	-50.00	-1.00	.32	43.75	0.87	.38	-14.29	-0.27	.79
Method of Measurement	-20.00	-0.37	.71	-12.50	-0.23	.82	-7.14	-0.14	.89
Number of Bugs	-13.33	-0.37	.71	50.00	1.44	.15	0.00	0.00	1.00

Appendix B
Instrument Descriptions

INTRODUCTION

This appendix describes the development and characteristics of the instruments used in the summative evaluation of the SS&C project. The SS&C project is a teacher enhancement process and set of materials for science education in grades 9-12, but the SS&C project and this evaluation were funded by the National Science Foundation for only the ninth grade portion. The SS&C project is committed to developing activities that produce students that are better prepared according to the National Research Council's Science Education Standards. As a result, these content and teaching standards served as the guidelines for the development of the assessment instruments used in this evaluation (National Research Council, 1995). This means that the SS&C project was evaluated on how well the curriculum prepared students based on the standards not on the specific goals or objectives of SS&C. The seven science education content standards have specific goals and objectives for the various grade levels: K-4, 5-8 and 9-12. The content standards are: science as inquiry, life science, physical science, earth and space science, science and technology, science in social and personal perspectives and history and nature of science.

The evaluation gathered data about students, teachers and schools at 5 sites nationally over a four year time frame. During the first year of the evaluation effort data were collected from students similar to those who would be receiving the SS&C curriculum during the following years. During the second, third and fourth years data were collected from SS&C students at the same schools where data were collected during the first year. All sites were visited by evaluation team members in the fall and spring of each year. Ten instruments were developed to assess student understanding of the content standards, student attitudes and motivation and the classroom environment in which these understandings were developed: a classroom observation schedule, principal, teacher and student interview protocols, a teacher questionnaire, a course content survey, a student questionnaire, a student hands-on full investigation test, a student laboratory performance test, and a student science literacy test.

The primary goal of the evaluation was to assess understanding of the content standards, therefore achievement was assessed in a variety of ways to help ensure validity of the findings. The students completed traditional multiple choice items, open ended items, a series of hands-on laboratory stations, a hands-on full investigation and a written full investigation. All of the assessment devices were administered by members of the evaluation team during site visits except the science literacy tests. The literacy tests were mailed out to the sites for the teachers to administer. To maintain confidentiality the tests were counted into classroom sets with class lists before mailing. Teachers were asked to not make copies of the tests and to return all used and unused copies. Standardized administration protocols were developed and read to the students at the beginning of each testing situation to insure consistency of administration.

Individual descriptions of each instrument follow. The student outcome measure instruments will be described first, followed by descriptions of those instruments designed to provide descriptive and environmental information.

STUDENT OUTCOME MEASURES

Science Literacy Test

The purpose of the science literacy test was to assess comparison and SS&C student understanding of the seven NRC science content standards. It was critical that this test contain science items deemed appropriate by a national audience so the items for the science literacy test were selected from existing tests such as NAEP, SISS, and IAEP. The items for those tests had been developed through a rigorous consensus and review process and thus represented a national perspective on appropriateness. Additionally the national data available for some of the items could be used as a comparison for the results from this evaluation. A team of science educators went through all of the available items independently and rated them on their relevancy to the new NRC standards and their appropriateness for ninth graders. The independent ratings were combined and any controversial items were discussed by the team to determine the value of including them. Care was taken to select both open-ended and multiple choice questions and to not overlap on content. Outside science education experts reviewed all of the finally selected items to confirm that the items were, indeed, consistent with the NRC standards. A draft

version of the Science Literacy Test was pilot tested locally with 9th grade students at both a suburban and an urban school to assess the length and difficulty of the test.

Twenty-six items were selected for each of the seven NRC science content standards, except for the technology standard which had only 16 items because additional national assessment items that matched the standard could not be located. Of the 172 items administered to students, 12 were open-ended and 160 were multiple-choice. Approximately 40% of the items were higher level reasoning items requiring at least application level understanding as defined by Bloom (1956) and Madaus (1989). The items were used to construct two parallel forms of the science literacy test. Half of the students in each class took form A of the test while the other half took form B. The test was administered to students by their teachers near the end of the school year over two 45-minute class sessions.

Multiple-choice items on the science literacy test were scored as either correct or incorrect. Because two parallel forms of the science literacy test were administered to students, standard errors were estimated using the bootstrap method (Efron & Tibshirani, 1993). The bootstrap method estimates the overall standard error of both forms of the test by taking the average of 200 randomly sampled standard errors. Comparisons between the years were made on the total score of all multiple-choice items, and on the multiple-choice items for each of the seven content standards. In the SS&C year, the Cronbach alpha reliability for the multiple choice items was .89 for form A and .88 for form B.

Lab Skills Test

The purpose of the hands-on lab skills test was to determine if there were any differences in the laboratory skills of the comparison and SS&C years. As with the science literacy test, in order to assure national acceptance of the items used, the instrument was developed from already existing and validated items. Each station was selected from existing national performance tests including the International Assessment of Educational Progress, the Assessment of Performance Unit (APU, 1981) and the British Columbia Science Performance Test (Bartley, Carlisle & Erickson, 1993). The five stations included determining density, chemical testing of starch and sugar solutions, using a microscope, testing and identifying rocks, and using measuring instruments. A draft version of the lab skills test and the full investigation described below were pilot tested locally with 9th

grade students at both a suburban and an urban school to assess the length and difficulty of the items, along with appropriateness of equipment and presentation.

The stations were administered by members of the evaluation team during the spring site visits and all of the equipment except for triple beam balances and microscopes were provided by the evaluation team to insure consistency of the test administration. At each school site, approximately 30 students took the lab skills test. Students who did not take the lab skills test were asked to complete the student questionnaire described below. The lab stations were set up in a classroom and the selected students rotated through the stations spending seven minutes working on each one. Each of the five stations was scored using the scoring scheme devised by the developers of that test. To calculate the score for each station, the various codes within each station were equally weighted. The scores on all five stations were equally weighted to calculate the total lab skills score. The score represents the mean percentage of possible points earned by the students. The intra-rater reliability of the scoring was assessed by re-scoring a random sample of 20 tests for each year. The 20 tests from the comparison year were also scored by another member of the research team to assess inter-rater reliability. The mean intra-rater reliability over both years was 93%, and the inter-rater reliability for the comparison year was 91%. The Cronbach alpha reliability for the lab skills test in the SS&C year was .84.

Full Investigation Test

The purpose of the hands-on full investigation was to demonstrate student ability to conduct an experiment as proposed in the NRC inquiry standard. The test asked students to design and conduct a complete experiment based on the classic "bugs test" developed by the Assessment of Performance Unit in the United Kingdom (APU, 1981). Students were given approximately 35 minutes to design, carry out and report the results of an experiment to determine which of the following environments isopods prefer: light and dry, light and wet, dark and dry, or dark and wet.

Each year two students were randomly selected to complete this assessment from each of the three classes observed at each site The students were given the necessary experimental apparatus and asked to draw their experimental set-up, describe it in writing and state their conclusions. Isopods, and various types of equipment like timers, sponges, black paper, containers, etc. were provided. A written version of this test (see the description of the student questionnaire below) was administered to students who did not

take the hands-on test. The written version was identical to the hands-on test, except students did not have materials and were instead asked to imagine and describe how they would perform the experiment.

The hands-on and written versions of the experimental design tests were scored in an identical manner using the APU scoring rubric that focused on aspects of the design and implementation of experiments. Five aspects of conducting an experiment were scored: 1) the number of environmental conditions presented to the isopods, 2) the extent to which access to different conditions was controlled, 3) the extent to which the amount (i.e. the area or volume) of each environmental condition was controlled, 4) the primary method of measurement, and 5) the number of isopods used to conduct the experiment. Each of the five parts of the score were equally weighted and placed on a scale from 0 to 10. A total score was calculated by adding the five parts of the score thus creating a score that ranged from 0 to 50.

Inter-rater and intra-rater reliability of the scoring of the hands-on full investigation test was checked by re-scoring a random sample of 20 tests from both the comparison year and the SS&C year. For the comparison year the inter-rater reliability was 85%, and the average intra-rater reliability was 91%. For the SS&C year the Cronbach alpha reliability for the hands-on full investigation test was .75.

Student Questionnaire

The purpose of the student questionnaire was to assess both students' perceptions of the learning environment as described in the NRC standards and students' attitudes and motivation. The questionnaire was 12 pages long and took about 30 minutes to complete. All of the appropriate ninth graders at each site except those selected for the hands-on testing completed the questionnaire. Responses to the items were directly inputted from the questionnaire and average ratings were calculated and compared across years.

The bulk of the questionnaire was a six scale learning environment inventory containing 37 items. The 5-point Likert scale items measured six aspects of the learning environment: 1) involvement, 2) difficulty, 3) relevancy, 4) critical voice, 5) experimental design, and 6) sequence. The involvement scale assessed students' perceived personal involvement in the classroom. The difficulty scale measured the students' perception of the academic difficulty in their classroom. The relevancy scale concerned the perceived relevance of

school science to students' out-of-school experiences. The critical voice scale assessed the extent to which students believe it is acceptable and beneficial to question a teacher's methods and knowledge claims. The experimental design scale examined the students' perception of the degree of open-endedness in the design of the experiments that were conducted in the classroom. The sequence scale measured the perceived sequence of classroom instruction, for example, whether or not the teacher used hands-on activities before lecturing to the class. All items were written in the personal form as recommended by Fraser and Tobin (1991), in order to more accurately elicit students' perceptions. The personal relevance and critical voice scales were taken intact from Taylor, Fraser and White's (1994) Constructivist Learning Environment Scale. The other four scales, experiment design, student involvement, sequence and difficulty, were developed by the evaluation team. The development consisted of selection, modification or invention of items based on other environment inventories. This was followed by a series of two field tests with samples of both urban and suburban 9th graders, reliability estimations and factor analyses. Based upon the results of the reliability analysis and the factor analysis, modifications were made to the items and the new items were field tested again with another sample of students. All items were also checked for readability and interpretation before field testing. The Cronbach alpha reliability for each scale on the learning environment instrument in the SS&C year was as follows: involvement, .70; difficulty, .79; relevancy, .76; critical voice, .80; experimental design, .55 and sequence, .61.

In addition to the learning environment items, the student questionnaire also requested demographic information; contained 24 items related to students' attitudes toward science; and contained the written version of the full investigation test. In the attitude section students were asked; what science activities they engaged in outside of school; what science courses they planned to take in the future; and their perception of the class as fun, interesting, relevant etc. The attitude and motivation items were responded to using a "yes-no" or 5 point, Likert format.

Both the written and hands-on full investigation tests were based on the classic "bugs test" developed by the Assessment of Performance Unit in the United Kingdom (APU, 1981). (The hands-on version of the full investigation test and the scoring applied to both was described previously.) The test asked students to design an experiment to determine which of the following environments isopods prefer: light and dry, light and wet, dark and dry, or dark and wet. The item was individually scored by a member of the evaluation team. Inter-rater and intra-rater reliability of the scoring of the written full investigation

test was checked by re-scoring a random sample of 20 written tests from both the comparison year and the SS&C year. For the comparison year the inter-rater reliability was 85%, and the average intra-rater reliability was 92% . The Cronbach alpha reliability for the written full investigation test in the SS&C year was .88.

DESCRIPTIVE MEASURES

Classroom Observations

Classroom observations were conducted to verify implementation of the SS&C curriculum and to document the behaviors in an actual classroom setting. In both the comparison and the SS&C years each site was visited twice, once in the fall and again in the spring. During each visit three classes, taught by three different teachers if possible, were observed. Classroom observations typically lasted for 45-50 minutes, depending upon the length of the class period. Given the limited number of classroom observations, these were viewed as supporting documentation, rather than as a primary data source.

The classroom observation form was developed from the descriptions of ideal science classrooms in the standards. The observation schedule was two pages long and had forty different items documenting several aspects of the learning environment including: student involvement, student and teacher questioning behavior, teacher rapport, cooperative group work as defined by Johnson and Johnson (1991), type of laboratory work as based on Schwab's levels of involvement, relevancy of content to the "real world", and critical voice of the students (i.e., the extent to which students believe it is acceptable and beneficial to question the teacher's methods and knowledge claims). The form also included items describing the setting and the equipment available. Throughout each observation period, the observers documented the most common form(s) of instruction that occurred during every 5-minute interval. In order to ensure consistency of use of the instrument, all of the evaluation team observed several classes locally using the schedule before it was finalized to achieve consensus of opinion on categorizations. As a final check after the first use of the schedule at the sites, the evaluation team members discussed what had been observed and decided how to best represent that on the schedule. As an additional attempt at consistency, the same observers conducted the site visits both years whenever possible.

Class profiles were created from the observation data by calculating the average percent of class time spent on various activities. The comparison year and SS&C years were compared to determine if there were a significant difference in the type of class activities. In addition, the ratings of teacher rapport, student involvement, critical voice, level of

open-endedness, relevancy, and type and number of teacher and student questions were compared between years.

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