A study of the long term impact of an inquiry-based science program on students' attitudes towards science and interest in science careers.

Helen Lussier Gibson
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A STUDY OF THE LONG TERM IMPACT OF AN INQUIRY-BASED SCIENCE PROGRAM ON STUDENTS' ATTITUDES TOWARDS SCIENCE AND INTEREST IN SCIENCE CAREERS

A Dissertation Presented
by
HELEN LUSSIER GIBSON

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ABSTRACT

A STUDY OF THE LONG TERM IMPACT OF AN INQUIRY-BASED SCIENCE PROGRAM ON STUDENTS’ ATTITUDES TOWARDS SCIENCE AND INTEREST IN SCIENCE CAREERS

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One reason science enrichment programs were created was to address the underrepresentation of women and minorities in science. These programs were designed to increase underrepresented groups’ interest in science and science careers. One attempt to increase students’ interest in science was the Summer Science Exploration Program (SSEP). The SSEP was a two week, inquiry-based summer science camp offered by Hampshire College for students entering grades seven and eight. Students who participated were from three neighboring school districts in Western Massachusetts. The goal of the program was to stimulate greater interest in science and scientific careers among middle school students, in particular among females and students of color.

A review of the literature of inquiry-based science programs revealed that the effect of inquiry-based programs on students’ attitudes towards science is typically investigated shortly after the end of the treatment period. The findings
from this study contribute to our understanding of the long-term impact of inquiry-based science enrichment programs on students' attitude towards science and their interest in science careers.

The data collected consisted of quantitative survey data as well as qualitative data through case studies of selected participants from the sample population. This study was guided by the following questions:

1. What was the nature and extent of the impact of the Summer Science Exploration Program (SSEP) on students' attitudes towards science and interest in science careers, in particular among females and students of color?

2. What factors, if any, other than participation in SSEP impacted students' attitude towards science and interest in scientific careers?

3. In what other ways, if any, did the participants benefit from the program?

Conclusions drawn from the data indicate that SSEP helped participants maintain a high level of interest in science. In contrast, students who applied but were not accepted showed a decrease in their attitude towards science and their interest in science careers over time, compared to the participants. The interviews suggested that students enjoyed the inquiry-based approach that was used at camp. In addition, students said they found the hands-on inquiry-based approach used at camp more interesting than traditional methods of instruction (lectures and note taking) used at school.

Recommendations for future research are presented.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>iv</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xiv</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>I. PROBLEM STATEMENT AND BACKGROUND</td>
<td>1</td>
</tr>
<tr>
<td>The Problem Statement</td>
<td>1</td>
</tr>
<tr>
<td>Background</td>
<td>4</td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td>6</td>
</tr>
<tr>
<td>Primary Evaluation Questions</td>
<td>7</td>
</tr>
<tr>
<td>Program Logic Model</td>
<td>7</td>
</tr>
<tr>
<td>Application of Logic Model</td>
<td>8</td>
</tr>
<tr>
<td>Significance of the Study</td>
<td>10</td>
</tr>
<tr>
<td>Nature and Design of the Study</td>
<td>11</td>
</tr>
<tr>
<td>Outline of the Dissertation</td>
<td>12</td>
</tr>
<tr>
<td>II. REVIEW OF THE LITERATURE</td>
<td>13</td>
</tr>
<tr>
<td>Introduction</td>
<td>13</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>14</td>
</tr>
<tr>
<td>Science Education Reform</td>
<td>19</td>
</tr>
<tr>
<td>The Inquiry Approach</td>
<td>26</td>
</tr>
<tr>
<td>The Inquiry Approach in Classrooms</td>
<td>34</td>
</tr>
<tr>
<td>Need for Implementation</td>
<td>37</td>
</tr>
<tr>
<td>Problems and Solutions for Implementation</td>
<td>38</td>
</tr>
<tr>
<td>A Significant Problem: Students' Self-Questioning Skills</td>
<td>41</td>
</tr>
<tr>
<td>Developing Students' Self-Questioning Skills</td>
<td>45</td>
</tr>
<tr>
<td>Collaborative Learning</td>
<td>47</td>
</tr>
<tr>
<td>Toward Improved Assessment</td>
<td>51</td>
</tr>
<tr>
<td>Assessment Methods</td>
<td>54</td>
</tr>
<tr>
<td>Summary</td>
<td>57</td>
</tr>
</tbody>
</table>
III. THE STUDY

Nature and Design of the Study ................................................................. 59
Quantitative Methods ............................................................................ 60

Survey Prior to the Summer Science Exploration Program .................. 61
Longitudinal Follow-Up ........................................................................ 62
Survey Instruments ............................................................................... 62

Qualitative Methods ............................................................................. 63

The Interview Protocol ......................................................................... 65
Interview Procedures ............................................................................ 66
Interview Guide ...................................................................................... 66
Levels of Evaluation ............................................................................. 68

Level I ................................................................................................. 68
Level II ............................................................................................... 69

Data Analysis .......................................................................................... 70
Pilot Study .............................................................................................. 71
Longitudinal Study ................................................................................ 74

Locating Students Who Applied But Were Not Accepted ..................... 79
Selecting Students for Interviews ......................................................... 80
Response Rate to Surveys ..................................................................... 80

Limitations of the Study ........................................................................ 82

IV. PRESENTATION AND ANALYSIS OF THE DATA ................................ 84

Data Analysis .......................................................................................... 84
Quantitative Results ............................................................................... 84

Comparison of SSEP and Non-SSEP Students ...................................... 84
Non-SSEP Students Over Time ............................................................... 87
SSEP Students Over Time ..................................................................... 91
Comparison of SSEP Students and Students Who Applied To the
Program But Were Not Accepted .......................................................... 93
The Effect of Variables .......................................................................... 95

Gender .................................................................................................... 96

Non-SSEP Students ............................................................................... 96
SSEP Students ....................................................................................... 98
Summary of Quantitative Results

Qualitative Results

Nature and Extent of Impact
Aspects of SSEP that Increased Students' Interest in Science
SSEP Students Learned Ahead
Factors that Affect Students' Science Attitudes
Factors that Make Science Classes Interesting
SSEP Students Considering Science Careers
Other Factors that Impact Students' Interest in Science

The Influence of Teachers
The Influence of Parents
The Influence of Schools Attended
The Influence of School Administrators
The Influence of After-School Programs
The Influence of Television
The Influence of Science Clubs

Other Ways Students Benefited

SSEP Increased Students' Interest in College
SSEP Increased Students' Social Skills
Aspects of the SSEP that Increased Students' Social Skills

Summary of Qualitative Results

V. CONCLUSIONS AND RECOMMENDATIONS

Changes Over Time
The Long-Term Impact of SSEP
The Long-Term Goal of SSEP
Impact of SSEP on Females and Students of Color
Summary
Recommendations for Future Studies ................................................................. 171

APPENDICES

A. SCIENCE OPINION SURVEY, CAREER DECISION-MAKING
   REVISED SURVEY AND STUDENT INFORMATION SHEET ...................... 174
B. CONSENT TO ACT AS RESEARCH SUBJECT
   AND LETTERS TO STUDENTS ............................................................... 179
C. ETHNICITY AND GENDER OF SSEP STUDENTS .................................... 188

BIBLIOGRAPHY ................................................................................................. 190
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Two sample t-test, Comparison of SSEP and non-SSEP students' science attitude means scores, 1992-1994</td>
<td>147</td>
</tr>
<tr>
<td>4.2</td>
<td>Two sample t-test, Comparison of SSEP and non-SSEP students' interest in science careers mean scores, 1992-1994</td>
<td>147</td>
</tr>
<tr>
<td>4.3</td>
<td>Two sample t-test, Comparison of SSEP and non-SSEP students' science attitude means scores, 1996-1997</td>
<td>148</td>
</tr>
<tr>
<td>4.4</td>
<td>Two sample t-test, Comparison of SSEP and non-SSEP students' interest in science careers mean scores, 1996-1997</td>
<td>149</td>
</tr>
<tr>
<td>4.5</td>
<td>ANOVA Table, Effect: school type * pre/post, Non-SSEP students' science attitude means scores</td>
<td>149</td>
</tr>
<tr>
<td>4.6</td>
<td>ANOVA Table, Effect: school type * pre/post, Non-SSEP students' interest in science careers mean scores</td>
<td>150</td>
</tr>
<tr>
<td>4.7</td>
<td>Paired t-test, Comparison of SSEP students' science attitude mean scores, pre/post</td>
<td>150</td>
</tr>
<tr>
<td>4.8</td>
<td>Paired t-test, Comparison of SSEP students' interest in science careers mean scores, pre/post</td>
<td>151</td>
</tr>
<tr>
<td>4.9</td>
<td>Two sample t-test, Comparison of SSEP students and students who applied but were not accepted post science attitude mean scores</td>
<td>152</td>
</tr>
</tbody>
</table>
4.10 Two sample t-test
Comparison of SSEP students and students who applied but were not accepted post interest in science careers mean scores...............................152

4.11 ANOVA Table
Effect: gender * pre/post
Non-SSEP students' science attitude mean scores..............153

4.12 ANOVA Table
Effect: gender * pre/post
Non-SSEP students' interest in science careers mean scores..............................................................................154

4.13 ANOVA Table
Effect: pre/post * gender
SSEP students' science attitude mean scores....................155

4.14 ANOVA Table
Effect: pre/post * gender
SSEP students' interest in science careers mean scores....155

4.15 ANOVA Table
Effect: Ethnicity * pre/post
Non-SSEP students' science attitude mean scores............156

4.16 ANOVA Table
Effect: Ethnicity * pre/post
Non-SSEP students' interest in science careers mean scores..............................................................................157

4.17 ANOVA Table
Effect: pre/post * Ethnicity
SSEP students' science attitude mean scores....................158

4.18 ANOVA Table
Effect: pre/post * Ethnicity
SSEP students' interest in science careers mean scores....159

4.19 ANOVA Table
Effect: City * pre/post
Non-SSEP students' science attitude mean scores.............160
4.20 ANOVA Table
Effect: City * pre/post
Non-SSEP students' interest in science careers mean scores

4.21 ANOVA Table
Effect: pre/post * City
1993 & 1994 SSEP students' science attitude mean scores

4.22 ANOVA Table
Effect: pre/post * City
1993 & 1994 SSEP students' interest in science careers mean scores

4.23 ANOVA Table
Effect: pre/post * pre Grade
SSEP students' science attitude mean scores

4.24 ANOVA Table
Effect: pre/post * pre Grade
SSEP students' interest in science careers mean scores

4.25 ANOVA Table
Effect: pre/post * Year attended camp
SSEP students' science attitude mean scores

4.26 ANOVA Table
Effect: pre/post * Year attended camp
SSEP students' interest in science careers mean scores

4.27 ANOVA Table
Effect: pre/post * Interview
SSEP students' science attitude mean scores

4.28 ANOVA Table
Effect: pre/post * Interview
SSEP students' interest in science careers mean scores
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>The Change Model</td>
<td>9</td>
</tr>
<tr>
<td>3.1</td>
<td>Telephone Contact Rate</td>
<td>78</td>
</tr>
<tr>
<td>3.2</td>
<td>Survey Response Rate</td>
<td>82</td>
</tr>
<tr>
<td>4.1</td>
<td>Non-SSEP students' science attitude mean scores (Effect: School type split by 92-94/96-97)</td>
<td>88</td>
</tr>
<tr>
<td>4.2</td>
<td>Non-SSEP students' interest in science careers mean scores (Effect: school type split by 92-94/96-97)</td>
<td>90</td>
</tr>
<tr>
<td>4.3</td>
<td>SSEP students' science attitude mean scores</td>
<td>91</td>
</tr>
<tr>
<td>4.4</td>
<td>SSEP students' interest in science careers mean scores</td>
<td>92</td>
</tr>
<tr>
<td>4.5</td>
<td>Comparison of SSEP students and students who applied but were not accepted (post science attitude mean scores)</td>
<td>94</td>
</tr>
<tr>
<td>4.6</td>
<td>Comparison of SSEP students and students who applied (post interest in science careers mean scores)</td>
<td>95</td>
</tr>
<tr>
<td>4.7</td>
<td>Non-SSEP students' science attitude mean scores (year split by gender)</td>
<td>97</td>
</tr>
<tr>
<td>4.8</td>
<td>Non-SSEP students' interest in science careers mean scores (year split by gender)</td>
<td>98</td>
</tr>
<tr>
<td>4.9</td>
<td>SSEP students' science attitude mean scores (pre/post split by gender)</td>
<td>99</td>
</tr>
</tbody>
</table>
4.10 SSEP students’ interest in science careers mean scores (Effect: pre/post split by gender)........................................................................100

4.11 SSEP students’ science attitude mean scores (Effect: pre/post split by ethnicity)........................................................................103

4.12 Non-SSEP students science attitude means scores (Effect: city split by pre/post)........................................................................105

4.13 Non-SSEP students’ interest in science careers mean scores (Effect: city split by pre/post)........................................................................106

4.14 1993 & 1994 SSEP students’ science attitude mean scores (Effect: pre/post split by city)........................................................................108

4.15 1993 & 1994 SSEP students’ interest in science careers mean scores (Effect: pre/post split by city)........................................................................109

4.16 SSEP students’ interest in science careers mean scores (Effect: pre/post split by pre grade)........................................................................111

4.17 SSEP students’ science attitude mean scores (Effect: pre/post split by year attended camp)........................................................................113

4.18 Female SSEP students’ science attitude mean scores (Effect: pre/post split by year)........................................................................116

4.19 Male SSEP students’ science attitude mean scores (Effect: pre/post split by year)........................................................................116

4.20 SSEP students’ interest in science careers mean scores (Effect: pre/post split by year)........................................................................117

4.21 SSEP students’ interest in science careers mean scores (Effect: pre/post split by interview)........................................................................119
CHAPTER I

PROBLEM STATEMENT AND BACKGROUND

The Problem Statement

The ethnic makeup of the United States is rapidly changing. The report published jointly by the American Council on Education and the Education Commission of the States in 1988, One Third of a Nation, states that by the year 2000 one-third of the population of the United States will consist of people of color or non-white Americans. The changing ethnic texture of the U.S. population has major implications for science education. Back in 1988, 85 percent of the students enrolled in science and engineering in U.S. colleges were white, 10 percent were African-American, and 5 percent were Hispanic (National Science Board, 1989). In addition, it was reported that in 1986, 87 percent of the 3.9 million scientist and engineers in the U.S. work force were males; 91 percent were white, 2 percent were African-American, 5 percent were Asian-American, and 2 percent were other.

The problem of underrepresentation of people of color in science starts when students are in high school. According to the 1990 U.S. Bureau of Census, 34% of white high school sophomores were enrolled in college preparatory programs, whereas only 26% of African American students, and 23% of Hispanic students were enrolled in such programs. In addition, there is a difference among different ethnic groups in the number of students who graduate from high school. Only 78.2% of all students who attend high school graduate. While 80% of white students graduate, only 68.5% of African American students, and 55% of Hispanic students receive their diploma.
Furthermore, the number of science courses taken in high school was lower for those underrepresented groups than it was for whites. Of the students who went on to college, 19% of white students had taken high school coursework that concentrated on science courses, while only about 10% of Hispanic students and 6% of African American students focused on science while in high school.

Continuing education in college is less likely for students of color than it is for whites. While 45% of white students who graduate from high school continue their education in college, only 30% of African American students and 27.8% of Hispanic students go on to college. Additionally, only 15% of the students of color who attend college major in science.

People of color are underrepresented in scientific careers. Although people of color make up 19% of the workforce, they only represent 9% of the science and engineering labor force (National Science Board, 1989).

Because of these striking differences a number of programs have been developed which seek to encourage students of color to increase their interest in science and scientific careers.

It is predicted that by the year 2020 students of color will make up about 46% of our nation's student population (Banks, 1991). Based on this information, I believe that science education should be restructured to increase the number of underrepresented groups in scientific careers. It is my opinion that ethnic diversity offers the opportunity to enrich science by providing new ways to view situations or events and new ways to solve problems. However, in order to be successful we need to change the way teachers teach and the way students learn in science classrooms to make science accessible and equitable to a diverse population of students.
The U.S. Department of Education’s National Assessment of Educational Progress (NAEP) results indicate that in 1986 science curricula and teaching methods stressed facts and rote skills and failed to impart critical thinking skills to most students. The NAEP report showed that in 1986 educational practices trained few students to use critical thinking skills. Yet, critical thinking skills are what students need to be successful in today’s business community and college classrooms. Many businesses want employees who are critical thinkers, who can solve problems, who have high quality speaking and writing skills, and who know how to learn. In addition, many college science instructors claim that students are unprepared for college level work. It is imperative that science teaching methods require students to use higher-order thinking skills.

Improving science education to educate “all students”, not just a select few, to be critical thinkers will not be possible if we do not change the way that science is taught. However, changes must be based on our understanding of how students learn.

The American Association for the Advancement of Science (AAAS) (1993) and the National Research Council (NRC) (1996) both endorse science curricula that actively engage students in science using an inquiry-based approach. This approach has shifted the focus of science education from the traditional memorization of facts and concepts in separate specific disciplines to inquiry-based learning in which students seek answers to their own questions. This approach is compatible with the constructivist conception of learning in which teachers encourage students to construct their own knowledge. This pedagogical approach emphasizes active learning, in which students make sense out of hands-on experiences.
Background

The purpose of this study was to evaluate the long term effects of the Summer Science Exploration Program (SSEP), an inquiry-based program, conducted at Hampshire College from 1992-1994. The SSEP was a component of a Science Education Partnership Award (SEPA) Project funded by two agencies of the U. S. Department of Health and Human Services: (1) the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA), and (2) the National Institutes of Health (NIH).

The main focus of this evaluation was to obtain information about the impact of the program on students' attitude towards science and interest in science careers.

Hampshire College was awarded a SEPA grant in partnership with Holyoke, Springfield, and Chicopee Public Schools (three neighboring school districts in Western Massachusetts). The goal of the program was to stimulate greater interest in science and scientific careers among middle school students in these communities, particularly among females and students of color. This was a three year project, conducted from 1992 to 1994. The program was developed in response to the widely noted underrepresentation of women and people of color in scientific careers.

The Summer Science Exploration Program (SSEP) focused directly on students. This was a summer science camp operated on the Hampshire College campus for students entering grades seven and eight. Over the three year grant period, a two week summer program was offered to 157 middle school students. In the first year (1992) it was a residential camp during the week only; students went home on weekends. In the second (1993) and third (1994) years it was a day camp; students were transported to Hampshire College and back home each day.
The SSEP provided students the opportunity to explore different biological and health related subjects through inquiry-based learning. Students who participated in this two week summer program learned science using an inquiry-based approach in which students learned how to formulate their own questions which could be addressed experimentally or through observation. Students designed experiments and practiced laboratory and field techniques that could be used to answer their questions. They also analyzed data through examining their own experiments and those of others. The college science labs provided students with the opportunity to engage in experiences that go beyond what the students experienced in their middle school science classes.

Selected middle school teachers worked together with Hampshire faculty and students to teach in the program. The college faculty brought access to the latest equipment and technology and extensive knowledge and experience in research. The middle school teachers brought highly skilled teaching capabilities and experience dealing with young teenagers. Together they were able to create an air of excitement and a sense of security. The summer camp program included courses in math, computers, and science, including subjects in Animal Science, Physical Anthropology, Health and the Biology of AIDS, Infectious Diseases, Agriculture and Food, and Nutrition. Each subject area was designed to excite students’ natural curiosity, to provide hands-on laboratory and field experiences, and to give students confidence that “they can do science”. In addition, guest speakers (women and people of color who worked in scientific and recreational fields) were invited to serve as alternative role models to help disprove the notion that science is only for white males.

Holyoke, Springfield, and Chicopee school districts were chosen for their proximity to Hampshire College, their demonstrated need for science education support, the demographics of their student population and because of a
successful partnership history on several earlier projects. The demographics were as follows: in 1992, 73% of Holyoke’s 7,420 students, 71% of Springfield’s 23,535 students, and 14% of Chicopee’s 7,191 students were Hispanic, African American, or Asian American. Over the three year grant period, about 40 percent of the SSEP students were Hispanic or African American. In addition, over half of the students in the SSEP were females.

In the SSEP program, application and screening procedures were used to ensure a balance in ability, gender, and ethnicity. Student applicants were stratified into these groupings, and then participants were randomly selected. They were randomly selected for two reasons. First, Hampshire College could not in good conscience devise a rational procedure for choosing one student over another. Second, Hampshire College wanted to test the effectiveness of these programs with students of all levels of ability and interest, not just the best and brightest or those interested in science.

**Purpose of the Study**

The goal of the SSEP was to increase middle school students’ interest in science and scientific careers, particularly among females and students of color. The focus of this longitudinal study was to determine the extent to which the Summer Science Exploration Program’s (SSEP) goal had been met and to point to supporting evidence. The overall question of interest is: Did the SSEP, which used an inquiry-based approach, have any long term impact on students’ attitude towards science and interest in scientific careers? If so, what was the nature and extent of that impact? Through this study I was able to share some insights into the potential long term impact of other similar inquiry-based science programs.
Primary Evaluation Questions

The primary evaluation questions addressed in this study:

1. What was the nature and extent of the impact of the SSEP (an inquiry-based program) on students’ attitude towards science and interest in scientific careers, in particular among females and students of color?

2. What factors, if any, other than participation in SSEP impacted students’ attitude towards science and interest in scientific careers?

3. In what other ways, if any, did the participants benefit from the project?

The overall longitudinal study was designed to answer questions related to whether the SSEP caused students to change their attitude towards science and interest in science careers. Through case studies of the experiences of a representative sample of student participants, this study yielded insights into what worked, what didn’t, and why.

Program Logic Model

It is useful to illustrate the relationship between the SSEP and the desired outcomes with a logic model. Wholey (1979) first promoted the idea of a “program logic model”. He applied this concept to the tracing of events from an intervention to the intended outcome. The intervention results in immediate outcomes; immediate outcomes in turn produce some intermediate outcomes which in turn produce the final or desired outcome. This model entails an awareness of a complex chain of events, leading from a short term intervention to the desired outcome.
The evaluation is based on a basic model of change. The model establishes a framework for analyzing change. The pre-existing condition (lack of interest in science and scientific careers, particularly among females and students of color), warranted change.

Application of Logic Model

The Summer Science Exploration Program (SSEP) provided students with the opportunity to experience inquiry-based learning in science for a period of two weeks in a supportive environment. The SSEP staff used an inquiry-based pedagogical approach in which students were allowed to seek answers to their own questions. This program was intended to lead to specific actions or changes in students’ attitude towards science and interest in scientific careers. For example, as a result of participating in SSEP, students may have increased their scientific knowledge, gained skills, improved their self-image, or changed their perceptions of scientists. These are immediate or short term outcomes. It is further expected that these short term outcomes may lead students into taking more than the required number of science courses in high school, planning on majoring in science at college, or pursuing a career in a science related field. These are intermediate outcomes. Such actions are taken because of students’ improved attitude towards science and interest in scientific careers. However, other external factors such as parents, community, teachers, schools, and other science enrichment programs might also have affected students’ attitude towards science and interest in scientific careers (see Figure 1).
Figure 1.1
The Change Model

Pre-Existing Condition:
Lack of interest in science and science careers among females and students of color

Intervention:
SSEP

Short Term Outcomes:
increase in scientific knowledge & skills, improved self-image, changed perception of scientist

Other External Factors:
parents, teachers, schools, other enrichment programs

Intermediate Outcomes:
taking more than the required amount of science courses in high school, planning on majoring in science at college, or pursuing a career in a science related field

Goal:
Increased interest in science and scientific careers, particularly among females and students of color
Significance of the Study

Programs like the Summer Science Exploration Program (SSEP) were developed in the early 1990’s in response to the widely noted underrepresentation of women and people of color in science careers.

Other similar programs were created such as the Science Enrichment Program (SEP) developed by the National Cancer Institute (NCI) of the National Institutes of Health to encourage underrepresented populations to pursue their interest in science, mathematics, and research and then go on into research careers in science. From 1990 to 1995, approximately 915 students, from around the country, participated in the SEP from four to five weeks during the summer. The program was held the first two years (1990 & 1991) at Hood College in Maryland. In 1992, the program decentralized to four separate organizations: University of Southern California in Los Angeles, University of Massachusetts at Amherst, University of Kentucky at Lexington, and the American Indian Science and Engineering Society in Boulder, Colorado.

The residential programs on these college campuses provided students who had just finished ninth grade with a host of academic, cultural, and recreational activities. All the SEP programs chose students who were motivated, interested in science, and had good grade point averages. The pedagogy used was a hands-on approach which allowed students to get directly involved in science, math, and laboratory research.

A post-hoc evaluation of the Science Enrichment Program (SEP) conducted by the Goodman Research Group in 1996 showed that overall the program goals were met over the short term. However, long-term evaluations of students’ continued interest in science, pursuit of science in college, and continuation in a science career were not conducted. Furthermore, the Goodman Research Group recommended that if similar programs are to be
funded, these programs should be required to include a component for tracking and assessment of the long-term goals. Tracking and follow-up of students is essential to provide evidence of the long-term impact of science programs.

The findings from the current study contribute to our understanding of the long-term effect of an inquiry-based science enrichment program (SSEP) on students' attitudes towards science and their interest in scientific careers. The results offer information that could be useful to curriculum planners when designing and implementing inquiry-based science programs.

**Nature and Design of the Study**

A review of the literature on inquiry-based science showed that long term impact studies are rarely conducted that measure students' interest in science over time. In this study, both quantitative and qualitative methods were used to determine the long term impact of the SSEP on students' attitude towards science and interest in science careers. Surveys were used, both prior to students' participation and several years after the program took place, to identify students' attitude towards science and their interest in science careers. This repeated measurement technique allowed me to measure change over time.

Through case studies of the experiences of the student participants I gained insights into what worked, what didn't and why. The interviews allowed me to explore factors, other than participation in SSEP, that impacted SSEP students' attitude towards science and interest in science careers. In addition, the interviews uncovered other ways in which the participants benefited from participation in the program.
Outline of the Dissertation

Chapter I  Introduction
   The problem statement, background, purpose of the study, and significance plus a brief outline of the study.

Chapter II  Review of the Literature
   An intensive search of relevant areas within the theme of inquiry-based learning in science education.

Chapter III  The Study
   In-depth description of the methodology, participants, and data collected.

Chapter IV  Findings
   An examination of the data collected from quantitative and qualitative methods to identify patterns from which conclusions might be drawn.

Chapter V  Conclusions and Recommendations for Future Study
   Conclusions drawn from this study and suggestions for future research that might be taken as a result of the research findings.
CHAPTER II

REVIEW OF THE LITERATURE

Introduction
Over the last 35 years science educators have advocated for an inquiry-based approach to learning (DeBoer, 1991). Today’s educational leaders, the American Association for the Advancement of Science (AAAS) (1993) and the National Research Council (NRC) (1996), together endorse science curricula that actively engage students in science using an inquiry-based approach. This method reflects the way that “authentic” science is practiced. “Authentic science” is inquiry-based; therefore school science education should be taught using an inquiry-based approach (AAAS, 1993; NRC, 1996). The inquiry-based movement has shifted the focus of science education from the traditional memorization of facts and concepts in one specific discipline to inquiry-based learning in which students seek answers to their own questions. This approach is compatible with the constructivist conception of learning in which teachers encourage students to construct their own knowledge.

The purpose of this review of the literature is to find answers to the following questions: What is meant by an inquiry-based approach in science education? Is this approach being used in today’s classrooms? What research has been done using inquiry-based approaches in classrooms? Are there problems that impede the use of this approach in classrooms? What are the implications of using inquiry-based approaches for science teaching and learning?
This review of the literature included an ERIC search using the following descriptors: "science education and inquiry," "discovery learning and science," and "science teaching and inquiry." This review is presented under the following headings: Definition of Terms, Science Education Reform, The Need for Implementation of an Inquiry-Based Approach, A Significant Problem: Students' Self-Questioning Skills, Collaborative Learning, Toward Improved Assessment, and a Summary.

**Definition of Terms**

As one reads through the literature about science education, many descriptive labels for the pedagogical approaches are used, such as: hands-on, activity-based, activity-centered, activity-oriented, lab-centered, student-centered, inquiry-based, discovery, guided discovery, inquiry-oriented, science process, process skills, process approach, method of science, minds-on, problem solving, and collaborative inquiry. What do all these labels mean? Are the labels different names for the same type of science education or are they really different approaches to science education?

The key terms from the above list are hands-on, process approach, and inquiry. These terms, like many in educational practice, are often used without a standard definition. The result is much confusion as one reads through the literature. Frequently researchers and other writers use the latest terminology without clarifying what is meant. In order to communicate effectively with others, reference to situations must occur in essentially the same way. If effective science instruction is the goal, then clarity of terms is an absolute requirement. I will define key terms to make it clear how I want the terms understood in the context of this study. I will also review how others have used these terms to demonstrate some of the confusion that is apparent in the literature.
Hands-on, in the context of this study, is defined as "contrived learning experiences in which students interact with materials to observe phenomena" (Hofstein & Lunetta, 1982, p.201-202). The experience is contrived when the teacher deliberately sets up materials for students to interact with. Everyone agrees that hands-on is differentiated from other methods of instruction, such as lecture and demonstration, by the criterion that students interact with materials. Hands-on science teaching departs from traditional science teaching (lectures and demonstrations). In the hands-on method, students themselves are allowed to handle materials and make observations.

This idea is not new in science education. The importance of object manipulation by students was stressed as long ago as the end of the 19th century, by the Committee of Ten (National Education Association (NEA), 1893). Furthermore, over the last thirty five years there has been a resurgence in science education which stresses the importance of learning from hands-on or direct experiences in addition to textbooks. The reality is that teachers and curriculum developers have long agreed that science courses should contain a significant amount of hands-on work.

Lumpe & Oliver (1991) refer to hands-on learning as being composed of three dimensions: inquiry, guided instruction and experimentation. Inquiry occurs when students make discoveries by collecting and interpreting information due to a desire or curiosity for understanding. Guided instruction is the direction that students are given by their teachers. Experimentation is confirming a discovery through controlled investigations. This definition is much broader than manipulation of objects by students. Others refer to the hands-on approach to science learning as inquiry, scientific process or problem-solving (DeBoer, 1991). Many at this point use the term hands-on as synonymous with inquiry. It reflects the current desire to make hands-on experiences in science
classrooms be more than just manipulation of objects by students. Today’s science teachers want students who can think critically about what they are doing. Therefore we sometimes hear the expression “hands-on, minds-on”.

**Minds-on**, in the context of this study, occurs when prior knowledge is restructured. Knowing and learning are inherently social and situated (Brown et al., 1989; Lave & Wenger, 1991; Newman et al., Saxe, 1991). Learners construct new forms of knowledge through collaborative interactions in specific settings. As with inquiry learning, this recognition (of the importance of the social context of learning) is not new in science education. John Dewey (1938) in his book *Logic: The Theory of Inquiry*, realized that inquiry was inherently social. He saw individuals as members of communities of inquiry. Dewey believed that through discussions with others, one strived to understand a situation. Sharing with others causes students to reflect on their own and others’ way of knowing (metacognition) which can result in restructuring prior knowledge.

**Verification lab**, in the context of this study, occurs when students carry out a laboratory investigation designed to confirm some scientific theory or concept. Students are basically trying to repeat what scientists have already discovered. This method emphasizes the facts and concepts of science. Students who use this method may get the impression that science is an accumulation of factual information, generalizations, and principles. Facts, concepts, and principles are the content of science. However, science is more than content and verification. Scientific conceptions are ‘ways of seeing’ developed within a community of science (Scott, Asoko, & Driver, 1991). Scientific knowledge is not fixed, static and unchanging. It is something that communities of scientists create. Science is constantly changing as new information comes to light or new perspectives are brought to our attention.
Independent inquiry, in the context of this study, occurs when students search for answers to their own questions. Students control what questions are being investigated and struggle for understanding. Dewey (1938) believed that inquiry begins because of some confusing, obscure or conflictual situation in which the inquirer is deeply involved. Teachers act as facilitators, while students learn content through inquiry.

H. E. Armstrong (1898) developed and popularized the independent inquiry method in England at the end of the 19th century. The questions for investigations came from the students as they examined materials they were presented with by the instructor. The purpose of Armstrong’s approach was to teach students how to learn, how to ask questions, how to carry out investigations, and how to find answers to their own questions.

Independent inquiry will produce students who are independent thinkers. Science needs independent thinkers, as Puckett, Cliatt & Shaw, point out in the following statement:

Many innovative scientists would never have made their most important discoveries had they been unable to think divergently in the pursuit of the new. Through thinking nontraditionally and divergently, scientists like Copernicus, Galileo, Pasteur, and Salk discovered solutions, formulated theories, and made discoveries that revolutionized the modern world. The need for divergent thinking did not die with their achievements. [1985, p. 15]

Guided inquiry, in the context of this study, is defined as a series of hands-on experiences, in an environment designed by teachers, that challenges students to make sense out of their discoveries. (Thus, it is redundant to label this approach hands-on, guided-inquiry). The teacher’s responsibility is to guide students to self-construct scientific concepts embedded in the hands-on activities. Guided inquiry is goal oriented.
Herbert Spencer and Thomas Huxley, respected and popular British scientists and essayists of the nineteenth century, had a lot of influence on the development of science teaching in both England and the United States. As early as the mid-nineteenth century, Herbert Spencer said “Children should be led to make their own investigations, and to draw their own inferences. They should be told as little as possible, and induced to discover as much as possible” (Spencer, 1864, p. 124-125). Spencer & Huxley argued for curricula to have science laboratory investigations in which students could make observations and use inductive reasoning. Their attack on classical curricula helped open the way for widespread inclusion of science education in curricula.

Spencer & Huxley were part of the Committee of Ten in the United States, which was formed in 1893 to decide what subjects should be taught at the secondary level, and how these subjects would be taught. The committee was established to help make the transition from secondary school to college smoother for students. The Committee of Ten believed the teacher’s role was to guide students to the appropriate generalizations. Alexander Smith, Associate Professor of Chemistry at the University of Chicago, and Edwin H. Hall, Professor of Physics at Harvard University, other committee members, felt that guided inquiry was a good middle ground between the extremes of verification labs and independent inquiry (Smith & Hall, 1902). They suggested that students should seek answers to questions for which they do not have answers. However, this did not mean that students had to discover everything on their own. Smith and Hall believed that, as long as students were initially unaware of the relationships being investigated, students were carrying out authentic science experiments. They felt that learning by independent inquiry was too slow; therefore they advocated for the use of guided inquiry. As a result the
Committee of Ten, back in 1893, supported guided laboratory-based instruction but not the independent inquiry advocated by some.

**Authentic science**, in the context of this study, occurs when all parties (students and teachers) involved do not know the answer to the question being investigated. Authentic science happens when people are puzzled about some actual event or object, and then design and carry out experiments to test their hypothesis. For this approach data are gathered, interpreted, and conclusions drawn. This information is then shared with the scientific community for feedback and modification.

The process that real scientists use to find answers to questions is often referred to as “inquiry” or “authentic science”. The inquiry approach involves all the activities that a scientist uses to find information such as, hypothesizing, conjecturing, reading, designing experiments, experimenting, collaborating with others, etc. However, it is important to note that authentic science is much more flexible than the rigid sequence of steps commonly called the “scientific method.”

In summary I have defined hands-on, minds-on, verification lab, independent inquiry, guided inquiry, and authentic science for the reader. In addition, I have reviewed the history and introduced the reader to some of the confusion that exists about the meanings of these terms. These definitions should help the reader understand more clearly my interpretation in the following discussion of inquiry-based learning, as I continue to review the literature.

**Science Education Reform**

In the late 1950s and 1960s, in response to the USSR launching Sputnik, the science curriculum in the United States was drastically revised.
Education was blamed for our failure to win the space race with the Soviet Union. As a result, the federal government initiated policies to improve science education. The motivation behind the science curriculum reform movement was the desire to make American science education the best in the world. As a result, it was hoped, the United States would produce more high quality scientists and engineers, enabling us to excel in the technology contributing to space exploration and beyond. The political agenda influenced our science educational goals. This burst of activity in curriculum development continued until the early 1970s. These national curriculum programs were funded by the National Science Foundation (NSF).

The materials that were produced, as a result of this movement, were intended to comprise a package of science curriculum that could be handed over to teachers. The federally funded curricula that emerged, such as Biological Science Curriculum Study (BSCS), Earth Science Curriculum Project (ESCP), Science Curriculum Improvement Study (SCIS), Science - A Process Approach (SAPA), Introductory Physical Science (IPS), Elementary Science Study (ESS), Chemical Education Materials Study (CHEMStudy), and Physical Science Study Committee (PSSC), to name a few, constituted a major break from traditional science curricula. These new curricula were based on an approach that encouraged students to find answers to questions that emphasized the "processes of science". As defined by Science - A Process Approach (S-APA) (AAAS, 1965), science process skills are transferable, applicable to many disciplines, and reflective of the true behavior of scientists. S-APA identified basic and integrated science process skills. The basic process skills are observing, classifying, communicating, measuring, using space/time relations, using numbers, inferring, and predicting. Basic process skills provide the foundation for learning the more complex integrated skills-
hypothesizing, identifying variables, operationally defining, designing investigations, and graphing and interpreting data.

Studies have shown that traditional science education presented an inaccurate picture of science by allowing students to believe that science was based on unchangeable truths. When students are taught using the traditional method, they often get the impression that science is textbook driven, difficult, boring and irrelevant to their lives; many learn to hate science (Hazen, 1991). The science curricula developed in response to Sputnik promoted the process approach as an effective method of learning. The belief of advocates was that if students could learn to think like scientists, more students would be interested in science. Also, science educators hoped that using the “process approach” would make students realize that science was something they could enjoy and do successfully.

In traditional science laboratory activities, the outcome was the only important part. By contrast, with the process approach doing the investigation was as important as the results. The reformers agreed that in traditional lab investigations, students merely verified facts presented in the text. Whereas, in the process approach, students were (supposed to be) allowed to generate their own conclusions based on observations.

This pedagogical approach emphasizes active learning, in which students make sense out of hands-on experiences. This approach is supported by “constructivism”. Constructivism is a theory that emphasizes the importance of students’ active construction of knowledge, based on experiences and prior knowledge. Connections are sought between prior knowledge and new experiences. These connections are constructed by the learner. The constructivist theory maintains that learners actively construct knowledge by seeking connections between prior knowledge and new experiences for the

In 1982, there was an analysis of 34 studies which compared the performance of students who participated in certain process approach programs (ESS, SCIS, and SAPA) with students in traditional, textbook-based classrooms (Shymansky, Kyle, & Alport, 1982). This analysis found that students in the classrooms using the process approach performed better (a 12-percentile-point gain) than 62% of the students in traditional classrooms in the all performance criteria measured: achievement, attitudes, process skills, related skills, creativity, and Piagetian tasks. They analyzed 21 studies of student attitude towards the new science curricula in comparison to traditional science programs. They looked at students' attitudes in three ways: 1) attitude towards new science course, 2) attitude towards science, and 3) attitude towards themselves. In all three categories student attitudes were more positive towards the new science programs than towards traditional programs. Many other studies of these federally funded curricula supported the findings that the process approach had favorable effects on students' science process skills, science attitudes, science achievement, and science content retained (Weber and Renner, 1972; Linn & Thier, 1975; Allen, 1973; Bowyer and Linn, 1978; Sheehan, 1970). This large quantity of research clearly showed that students in these programs liked science more, achieved more and improved their skills more than students in traditional, textbook-based classrooms.

However, in the later half of the 1970s, major evaluations of these curricula were conducted which showed that the materials created were being used by only a few elementary teachers, while more high school science teachers were using the materials (Research Triangle Institute, 1977; Weiss, 1977). The National Survey of Science Education Curriculum Usage.
conducted by the Research Triangle Institute (1977) under contract to the National Science Foundation (NSF), found the most extensive usage of the federally funded curriculum materials was in science in grades 7-12; 60% of the school districts were using one or more of these materials and 41% were using more than one. At the K-6 level, only 31% of the districts were using one or more of the science curriculum materials. Another study, *The 1977 National Survey of Science, Mathematics, and Social Studies Education*, conducted by Iris Weiss revealed: 1) Science instruction in elementary grades received considerably less time than mathematics and reading instruction; 2) Federally funded science curriculum materials were being used in a majority of the nation's school districts; 3) Sizable numbers of teachers wanted additional help obtaining information about instructional materials, learning new teaching methods, implementing the discovery/inquiry approach, and using manipulatives. Why weren't these programs being used by elementary school teachers after so much time, effort and money had been invested by the federal government?

One reason may be found in the same survey. Weiss found that almost 50% of all high school science teachers had participated in one or more NSF-sponsored in-service workshops, conferences, or institutes. However, only about 30% of middle school teachers, and less than 15% of elementary school teachers had participated. It is interesting to note that the survey showed that teachers who attended one or more NSF-sponsored workshops were more likely to use manipulatives in their classrooms than teachers who had not been trained in this method. Additionally, it was discovered that, although many teachers were trained in these new curricula, some did not get the help they needed to implement the programs back in their own schools. Overall, these studies found that many teachers using the new curriculum materials were not
using hands-on laboratory investigations. Instead, they were still using lectures and demonstrations, often in order to maintain classroom control.

Furthermore, it would appear that many science teachers who were supposed to be using the “process approach”, supposedly contained in these new curricula, were often leading students to expected conclusions rather than guiding them to self-construct scientific concepts embedded in laboratory investigations. The “process approach” of the 1960s and 1970s did have the virtue of requiring learners to be physically active, but most of these laboratory-based investigations required students to simply follow directions. Most of the new science curricula designed in the 1960s failed to convey the nature of scientific inquiry (Herron, 1971). There was no space in the curriculum for students to ask and investigate their own questions, as steps were clearly laid out for students to follow (Tamir & Lunetta, 1981). Students were introduced to concepts through lab investigations before going on to read about these concepts in the text. Teachers and students were often still looking for the “one right answer.” Thus, this type of teaching was similar to verification labs.

The above studies demonstrate that there is still a need for many teachers to get away from making students engage in rote memorization. More teachers need to guide students to hypothesize, conjecture, construct explanations, and collaborate with others. These are features that require critical thinking. Textbooks should be used as one of many possible sources of information that students can use to extend their knowledge. However, teachers need to encourage students to use many diverse sources of information such as hands-on materials, books, people, computers, videos, etc. When we allow students to explore, we see that it is unreasonable to expect students to come up with “one right answer”. Educational leaders have come to
realize that we need a more "authentic" science approach, such as inquiry-based learning.

The focus of curriculum reform has moved from keeping pace with the Soviets to concerns about equitable education for all. The National Science Education Standards (NRC, 1996) maintains that all students should be given the opportunity to learn science regardless of age, sex, cultural background, socio-economics, etc. In addition, the Standards are designed to give all students the opportunity to achieve an understanding of science concepts in the form of multiple experiences over several years. The inquiry-based approach advocated for in the Standards allows diverse communities of students to share their personal experiences and cultural backgrounds, in order to construct meaning. Diverse students understand science in different ways and at different levels. However, classroom discussions allow students to verbalize their ideas and perceive that others may have different perspectives. Additionally, listening to alternative interpretations may cause students to reconsider their own thinking.

Today, the goal of science education is to construct settings that create a sense of unity amidst diversity and enable meaningful reflection, exchange and growth. An important point is that there is not "one correct way" to construct meaning from events. Multiple explanations are possible. When only one correct explanation is allowed, we are oppressing individuals (Freire, 1993). By allowing other explanations, we create the opportunity to transform our understanding. It's like looking at the world through a different set of lenses or "conceptual spectacles" as Driver (1983) would say. Lenses which provide a different way to make sense of the world. Furthermore, Bruner (1990) points out that "open mindedness is a willingness to construct knowledge and values from multiple perspectives without the loss of one's own values" (p. 30). Being open
minded allows us to see other's perspectives, yet we can still continue to have our own beliefs and values. It is possible to be able to understand different interpretations without believing in them (Driver, 1983).

According to the NRC as outlined in the Standards, the educational goal is to produce both a scientifically literate work force and a scientifically literate citizenry. That is, we want to generate citizens who understand science and its role in society. This goal gained popularity when the National Science Teachers Association (NSTA), in its position statement on School Science Education for the 70s, identified it as the most important goal of science education. The goals and reasons for curriculum reform have changed over time. Additionally, the pedagogy advocated for has changed from a process approach to an inquiry approach, in which students are actively engaged using both science processes and critical thinking skills as they search for answers to their own questions.

The Inquiry Approach

Inquiry is both a way of teaching and a way of learning. Teachers who use an inquiry approach allow students to explore in ways that are personally and intellectually meaningful. The inquiry approach allows students to connect classroom activities with their everyday experiences. In contrast, traditional science learning has little or no connection to students' everyday lives (Papert, 1980). The importance of a problem due to its personal relevance has received attention since Dewey (1938). Learning that is relevant to students' lives motivates them to learn and gives them skills needed to be productive members of society.

Teachers who use the inquiry approach require students to work with others while asking questions and searching for and selecting information to
answer their own questions. Inquiry-based learning occurs when students do not have a clear understanding of the concept to be learned before conducting an investigation. According to Piaget the "goal of education is to form minds which can be critical, can verify, and not accept everything offered" (1964, p.5). Inquiry-based learning empowers students to become independent learners.

Many studies have compared an inquiry-based approach to the traditional lecture and demonstration approach. Saunders and Shepardson (1984) point to the importance of inquiry in students' learning. They studied the effect of two different kinds of instruction: "formal" and "concrete" instruction. They investigated the effect of these two kinds of instruction upon science achievement and intellectual development of sixth grade students. The first kind, formal instruction, emphasized the oral and written language. It included lectures, discussions, oral quizzes, written assignments, reading assignments, films, film strips, written tests and quizzes. Students in the formal instructional group did not perform any lab investigations and did not manipulate any science equipment. The second kind, concrete instruction, was organized around the three-phase learning cycle approach (exploration, conceptual invention, and discovery) and emphasized hands-on activities. During the exploration phase of concrete instruction, students use process skills such as observing, measuring, experimenting, interpreting, and predicting. The conceptual invention phase consisted of teacher-led discussions about the hands-on activities. The discussion can be described as guided inquiry ended with an explanation or interpretation. The discovery phase expands the concept through further experimentation, discussion, reading, and audiovisual materials.
In this study, students were randomly assigned into the two treatment groups. Pretest and post-test measures were administered for the two dependent variables: reasoning and science achievement. Reasoning was measured with Lawson’s Classroom Test of Formal Reasoning (1978). Science achievement was measured with teacher made tests that covered the sixth grade general science curriculum. Comparison of the pretest of the two treatment groups, at the beginning of the study, showed no difference in science achievement or cognitive ability. However, after nine months of treatment, the post-test revealed that the concrete instruction group scored higher in science achievement and cognitive development than the formal instruction group. These results indicate that hands-on science activities have positive effects on students’ science achievement and intellectual development.

Padilla, Okey & Garrand (1984) found that sixth and eighth grade students can learn to use certain integrated process skills. In this study, one group of students (extended process skill group) were involved in a two-week introductory unit on integrated process skills (controlling variables, interpreting data, formulating hypothesis, defining operationally, and experimenting) followed by one period-long process skill activity per week for 14 weeks. A second group was involved in only a two-week introductory unit on integrated process skills. A third group, the control group, received no direct instruction on integrated process skills.

Two sixth and two eighth grade teachers were selected to participate in this study based on their reputations as effective science teachers. Each teacher taught all three treatment methods to heterogeneous groups of students. Classes were randomly assigned to each treatment method for 14 weeks. All students were pre- and post-tested using the Test of Logical
Thinking (TOLT) and the Test of Integrated Process Skills (TIPS) (Dillshaw & Okey, 1980).

No differences were found in logical thinking with either grade level. In addition, when the logical thinking test was subdivided into five categories: 1) identifying variables, 2) proportional reasoning, 3) correlational reasoning, 4) combinational reasoning, and 5) probabilistic reasoning, no differences were found at either grade level. No process skill (TIPS) differences were found for sixth graders among the three treatments. However, statistically significant differences in process skills were found among the treatments for eighth graders. In comparing the three eighth grade groups, group one had significantly higher scores in process skills than the two-week process skill group or the control group. To find out which process skills improved the most the process skills test was divided into three subtests: 1) identifying variables and stating hypothesis, 2) measuring and experimenting, and 3) graphing and interpreting data. The results of these subtests revealed that both sixth and eighth graders had significantly improved in identifying variables and stating hypothesis. However, no differences were found for the other two process skills subtests. Overall, these results indicate that extended periods of instruction in process skills are more beneficial to eighth grade students than brief introductory units in process skills.

Mattheis & Nakayama (1988a) investigated the effects of a laboratory-centered inquiry program on laboratory skills, science process skills, and knowledge/ understanding. They compared the inquiry approach used in the Foundational Approaches in Science Teaching (FAST) program to a traditional science textbook approach. FAST was developed by the Curriculum Research and Development group of the University of Hawaii. The FAST program is an
interdisciplinary science program which emphasizes foundational concepts and methods of the physical, biological, and earth sciences as well as the application of this knowledge to environmental problems (Pottenger & Young, 1983). Approximately 60 to 80% of class time is spent by students on field or laboratory investigations. The remainder of the time is spent on the analysis of data and class discussions. The teacher acts as a research director-facilitator, challenging students, setting tasks, asking questions, giving suggestions for further investigations, and helping students evaluate their outputs and competencies.

Students work in groups to identify problems, formulate hypothesis, and report their findings to their peers for critical feedback. In FAST 1 students investigate the local environment to discover the basic principles of biological, geological, physical, and meteorological science. Data, for the most part, point to specific conclusions. Students develop skills designing experiments, collecting data, interpreting results, and using laboratory equipment.

Two FAST and two non-FAST teachers in sixth grade and two FAST and five non-FAST teachers in seventh grade participated in this study. Teachers who taught using the FAST program were certified for teaching FAST 1 through a two-week FAST 1 teacher training program and had a least one year of experience in their science classes before this investigation. All non-FAST teachers had neither experience. All classes were heterogeneous groups of students that represented the ability, socio-economic levels, gender, and race of the local school district.

In this study, the treatment group, the Fast 1 program was integrated into a regular science curriculum at both sixth and seventh grades for one school year, while the control group continued with the regular science curriculum. It was assumed that in the regular science classes (control groups) traditional
teacher-oriented, lecture-demonstrations approaches would be predominant and students would get less hands-on experience of laboratory-oriented inquiry compared to the experimental groups.

At the end of the year, post-tests were administered to both groups. The following three evaluative instruments were used. The **Performance of Process Skills Test** (POPS) by Mattheis, & Nakayama (1988b) was used to assess six integrated process skills in science. The **FIN Test** by Fukouka, Pottenger, Ishikawa, & Nakayama (as cited in Mattheis & Nakayama, 1988a) was used to evaluate basic science knowledge. The **Laboratory Skills Test** (LST) by the Curriculum Research and Development Group (as cited in Mattheis & Nakayama, 1988a) consisted of three parts: LST- Part 1 was used to assess practical laboratory skills. LST-Part 2 was used to assess the process skills of graphing and interpreting data. LST-Part 3 was used to assess knowledge and understanding of the density concept.

A Multivariate Analysis of Covariance (MANCOVA) of the three dependent variables (the POPS, FIN, and LST scores) showed that student laboratory skills, integrated science process skills, and understanding of science knowledge as a whole seem to be affected by the FAST 1 program at both grade levels. To examine the effects of each individual dependent variable by each grade, a univariate Analysis of Covariance (ANCOVA) was conducted. Statistically significant differences on the LST total score were found between the FAST and non-FAST groups for both sixth and seventh graders. However, the POPS and FIN total scores showed no differences between the two treatment groups with either grade level.

To find out which laboratory skills were different between the two treatment groups the LST test was divided into the three subtests: practical laboratory skills (LST-Part 1), process skills of graphing and interpreting data
(LST-Part 2), and knowledge and understanding of density concept (LST-Part 3). Statistically significant differences were found between the FAST and non-FAST groups in the practical laboratory skills subtest and the process skills of graphing and interpreting data subtest for both sixth and seventh graders. However, no statistically significant differences were found due to treatment on the knowledge/understanding subtest for the seventh graders, whereas statistically significant differences were found for the sixth graders. Results from the ANCOVA indicate that laboratory skills and specific science process skills such as graphing and interpreting data were enhanced by the laboratory-centered inquiry program (FAST 1) at both grade levels. Overall, this study is evidence that the integration of a laboratory-oriented inquiry approach (the FAST program) into a regular science curriculum for a period of one year improves students' laboratory skills, science process skills, and understanding of science knowledge as a whole.

Some studies have shown that students who use an inquiry approach have improved attitudes towards both science and school while other studies show more negative attitudes resulting from traditional methods. Perhaps this improved attitude is because inquiry-based learning capitalizes on students' natural curiosity about events and materials. Unfortunately this natural curiosity is often stifled in science classrooms. Harty and Enochs (1985) reported that approximately one-third of all students dislike science by the end of third grade. Traditional school science often results in the formation of negative attitudes towards science and science anxiety. In contrast, Selim & Shrigley (1983) found that students taught by teachers using an inquiry approach had a more positive science attitude and also scored higher in science achievement than students taught using a traditional approach. They compared the effectiveness
of two instructional modes, discovery and expository, for teaching science knowledge. They tested recall, application, and science attitude of fifth grade male and female Egyptian students. The treatment period was twelve 45 minute science classes over a 21 day period.

Jaus (1977) compared a hands-on science method to a textbook approach with second, third and fourth grade students from a lower socioeconomic school. There were two classes at each grade level with approximately twenty-five students in each class. First he randomly selected and trained one teacher from each of the grade levels to teach science using a hands-on approach. Then these teachers implemented this method in their classrooms for three hours a week for 12 weeks. The teachers who did not receive training continued teaching science using the textbook approach: reading, and answering questions at the end of the chapter. He discovered that not only did an inquiry approach significantly improve student's attitudes towards science but their attitudes towards school were also significantly improved.

Perhaps inquiry-based learning is a more effective way for students to learn science (Hodson, 1990), or possibly science learning improves when students' attitudes are positive. In summary, the above studies indicate that students who learn science using an inquiry-based approach attain a significantly higher level of science achievement and cognitive development, improved reasoning, laboratory and science process skills, as well as improved attitudes towards both science and school, when compared to students taught using a traditional approach. In addition, other studies have confirmed that an inquiry approach promotes the cognitive development and science achievement of students (Purser and Renner, 1983; Schneider and Renner, 1980; Wollman & Lawson, 1978). The above studies all investigated the
influence of inquiry-based science in comparison to traditional science at the end of a treatment period, which ranged from 21 days to 1 year. It appears from my review of the literature that studies have not been done which explore the long term (several years after the treatment) impact of inquiry-based science instruction.

The Inquiry Approach in Classrooms

There is some confusion about what inquiry-based learning looks like in science classrooms. Some educators associate inquiry with structured methods of guided inquiry. Others link inquiry with independent inquiry.

Many high school biology teachers currently use a guided inquiry laboratory approach developed by Biological Sciences Curriculum Study (BSCS). The BSCS Green Version high school biology textbook, Biological Sciences: An Ecological Approach contains more than 40 laboratory investigations. The investigations provide a foundation for the development of biological concepts and science process skills. Igelsrud & Leonard (1988) found that in BSCS students are given sufficient directions to proceed successfully through investigations while maintaining certain aspects of inquiry. The key aspect of the guided inquiry approach in BSCS is for students to engage in science processes. However, while the guided inquiry approach in BSCS allows students to discover biological concepts, it remains weak in providing necessary experiences for development of problem solving and critical thinking skills. Students are not taught to think when lab investigations consist of a detailed list of materials and equipment needed, procedures to follow, data to collect, calculations to make, and questions to answer. Students who learn science using a guided inquiry approach are not given the opportunity to make decisions about how to conduct an investigation. They are
engaged in "cookbook labs" that only train students to follow directions. This is not authentic science. The Massachusetts Department of Education's Science and Technology Curriculum Framework states that "the goal of inquiry based learning is for students to become questioners -- not just to know the questions, but to own the questions" (January 1996, p. viii).

Students taught using laboratory investigations such as BSCS are not required to exercise independent inquiry. The question of interest is: Are students able to carry out independent inquiry in science classrooms? According to Leonard, Cavana & Lowery (1981) tenth-grade biology students, when given training and the opportunity, are capable of independent inquiry. They compared the BSCS Green Version laboratory program with an Extended Discretion (ED) laboratory approach. The Extended Discretion approach did not contain step-by-step procedures for students to follow. In addition, in the Extended Discretion approach, students were asked to be as independent of the teacher as possible. Students who learned using the Extended Discretion approach produced higher quality lab reports, and demonstrated greater understanding of lab concepts than students taught using the BSCS Green laboratory program. This study found that students were able to learn on their own for only short periods of time (10-15 minutes) at the beginning of the year. However, later in the school year, students were able to learn on their own for longer periods of time (at least three class periods). The most significant finding from this study is that the ability to learn independently can not only be expected of students, but that it also improves over time as students adjust to new teacher expectations.

Michael Tinnesand, a biochemistry and chemistry teacher, and Alan Chan, a physics and chemistry teacher, use "instructionless labs" that pose inviting puzzles for students to solve (Tinnesand & Chan, 1987). Instructionless
labs, unlike cookbook labs, do not consist of detailed list of materials and equipment needed, procedures to follow, data to collect, calculations to make, and questions to answer. Instead, students must use their own knowledge of concepts to develop their own procedures. Tinnesand & Chan claim:

A key advantage of the instructionless lab format is that students develop critical thinking skills such as the ability to decide what to do, how to do it best, what data are important, how accurate their measurements must be, and why each step in the process is necessary. [1987, p.44]

They emphasize that it is crucial to present problems that students are able to solve using their knowledge, available equipment, and laboratory skills. The key point is that students use critical thinking skills when they are allowed to solve problems on their own.

Freire (1993) speaks of the banking concept of education versus a problem solving approach. The banking concept is what has been traditionally used in classrooms, where knowledge is considered to be static and transferred from the teacher to the student. Freire maintains that a liberating education consists of acts of cognition, not transferals of information. A problem solving approach is liberating, humanistic and challenging. This method understands that knowledge is not static but constantly being transformed through collective action that is steadily evolving (Grant, 1992).

When students solve problems using the structured “guided inquiry”, they are solving the problem that their teacher has set for them. In this situation the student’s problem is to find out what the teacher wants (Dewey, 1916). On the other hand, problem solving or independent inquiry allows for “knowing what to do when you don’t know what to do” (Schon, 1983, p. 169). In problem solving or independent inquiry, students are allowed to decide what to do and how to
do it. They are empowered by their teachers to derive conclusions independently.

**Need for Implementation**

In spite of all the studies cited above that show the benefits of inquiry-based learning, it is still far less frequent than lectures and demonstrations (Howe, Blosser, Helgeson, & Warren, 1990). The 1985-86 National Survey of Science and Mathematics Education, conducted by Weiss, revealed that the use of hands-on investigations by secondary science teachers had declined from 50% in 1977 to 39% in 1985-86. In addition, Mullis & Jenkins (1988) in *The Science Report Card* found only 44% of seventh graders and 40% of third graders had done any hands-on science activities in the previous month.

Furthermore, most science curricula show little evidence of inquiry. The majority of students still participate in science investigations referred to as “cookbook labs”, in which every step of an investigation is described for students. Following directions might at times produce good cooking, but it does not produce good scientists. Cookbook science is not considered authentic science. Lumpe & Oliver (1991) have characterized cookbook labs as “hands-on, minds off”. They argue that in cookbook labs, inadequate attention is being paid to the content and processes of science.

Throughout the last thirty-five years there has been a great deal of debate over the learning of the processes of science versus the content of science. Over this period many new curricula were created that emphasized the processes of science. At the same time, many teachers were still expected to cover a great deal of content material. The objective of many science educators has been to change practice from traditional science education to one that used an inquiry-based approach. However, inquiry-based learning has not been incorporated in science classrooms to the extent that science
educational leaders had hoped it would be. In many science classrooms there still seems to be a greater emphasis on the coverage of facts and information. According to Newmann (1980) "the addiction to coverage fosters the delusion that human beings are able to master everything worth knowing" (p. 346). While the change to a inquiry approach may seem worthwhile, teachers may feel anxious about not covering content. This is not surprising when we realize that most teachers were taught science using a traditional approach that emphasized facts and information. It is well known that teachers teach the way they were taught (Tilgner, 1990; Wallace & Louden, 1992).

The need for teachers who are able to use the inquiry approach is evident in the studies cited above. Therefore, if educational leaders want inquiry-based learning to occur in more science classrooms, we have to prepare science teachers differently. Future teachers need to learn science the way educational leaders want students to learn science; that is, using an inquiry-based approach. If teachers continue to learn science through lecture and note-taking (memorizing facts), with "cookbook labs", they will not be able to teach science using an inquiry method (Stedman, 1974).

Problems and Solutions for Implementation

Despite all the effort that has been placed on restructuring elementary science education, many programs have not been successful. A number of important factors have been suggested in explanation, such as shortage of equipment (Biddulph, 1982), elementary teachers' lack of background in science (Plimmer, 1981; Symington & Osborne, 1983), and too much teacher preparation time required (Appleton, 1977).

The process approach had problems because it did not take into account the following factors: 1) It ignored students' existing ideas. 2) It didn't take into
account students' everyday lives. 3) It assumed that the processes of science were content-free, generalizable and transferable from one context to another. 4) It ignored the nature of systemic reform (Hodson, 1988).

Teachers have their own concerns that prevent implementation. Many recent programs have emphasized hands-on learning. As a result numerous elementary teachers received the message that students should be constantly interacting with materials. Some teachers believe that hands-on is the only acceptable form of science teaching in the elementary classroom. However, sometimes when teachers and students use hands-on activities, they lose sight of the purpose of the activity. Manipulation of materials and objects does not necessarily lead to the modification of students' existing ideas. For many teachers fostering student inquiry is not the goal of hands-on activities. Instead, learning the correct concepts is still the goal. Hands-on activities becomes a way for teachers to transfer knowledge to students instead of becoming a way to stimulate their thoughts and modify their understanding of concepts. Under these conditions hands-on becomes minds-off learning. Hands-on by itself is not sufficient for learning in science (Roychoudhury, 1994).

Other teachers have classroom management problems. And there is concern about assessment. Teachers are also concerned about organizing the necessary resource material. Also, some teachers have anxiety about doing science. Others find it difficult to choose topics to study. These problems have not been taken into account when designing science programs (Symington & Osborne, 1983).

Recent programs for science in elementary schools not only advocate for hands-on activities, they also advocate for students working in small groups. This is difficult for teachers in classrooms which were not designed for these
kinds of activities. Also, teachers don't know how to evaluate hands-on collaborative learning. Traditional methods of assessment that measure students' content knowledge are inappropriate for an inquiry approach.

Hands-on science involves the use of lots of materials. As a result, storage can became a problem. Many classrooms do not have enough space to store needed materials. Teachers must also maintain and organize these materials. Thus, it is not surprising that many teachers feel that textbook teaching is easy, compared to using the hands-on approach. Some teachers think that using textbooks is more organized and disciplined, whereas they see inquiry-based learning as noisy and unpredictable. Also, when teachers are accustomed to covering the material in the text, they think that an inquiry-based approach takes too much time. They think they won't have time to do both inquiry-based learning and cover the material in the text. They don't understand that textbooks can be used in an inquiry-based approach as a source of information, but not as the curriculum. Therefore, teachers who want to use the inquiry approach should first decide what major concepts should be taught, and then use the inquiry-based approach to support the learning of those concepts.

We need to advance teachers' knowledge of acceptable inquiry in science beyond leading students to predetermined objectives. The goal of science education is to elicit students' thinking, in an environment where students are both capable and allowed to express their own opinions. Some teachers may not have the skills needed to plan an effective inquiry-based science program. However, Hall (1989) found that pre-service teachers who were taught using the inquiry-based approach had improved formal reasoning skills, reduced science anxiety, and increased science content learned. In addition, Bredderman (1984) found that teachers who are trained using an
inquiry-based approach do spend more time using this method than untrained teachers. Furthermore, Parsons & Smith (1968) reported that teachers are capable of learning how to ask questions that promote student inquiry. The above research supports that teachers can be taught how to carry out inquiry-based learning in their classrooms.

However, problems arise because the inquiry-based approach to learning science implies change for many educators: including teachers, administrators, and others involved in implementing educational policy. Teachers, however, are the ones most affected, and they often are the ones that determine the extent of implementation. The change from a traditional lecture, content-oriented, teacher-centered, textbook-dependent way of teaching to an inquiry-based approach is particularly difficult for many teachers (Martens, 1992).

**A Significant Problem: Students' Self-Questioning Skills**

I believe that one of the most significant problems that interferes with implementation of the inquiry approach in science education is that students do not know how to ask their own questions. Their natural curiosity has been stifled by years of traditional schooling. Yet, inquiry-based learning requires students who can ask their own questions. I have identified in the literature several factors which may interfere with students' self-questioning skills such as: time, teacher fears, the social structure of the classroom, and students' own insecurities.

Students are often not given time to generate their own questions. According to Mary Budd Rowe (1974a, 1974b), in a typical classroom, the length of time a teacher pauses after asking a question before acknowledging a students' response (also referred to use wait-time I) last only five tenths (.5) of a
second to one and two tenths (1.2) of a second. This does not allow students much time to think if they want to respond. Many students need longer uninterrupted periods of time to think. They need time to process information, reflect and consider their own personal response. In addition, post student’s response wait time (wait-time II) is the amount of time between a student’s response and the next response or interaction. In this time both students and teachers are thinking about their reactions to what was said. Teachers as well as students need time to process information and decide how to proceed. Many researchers have discovered that increasing both types of wait-time to three or more seconds has many positive influences (Casteel and Stahl, 1973; Rowe 1974 a,b; Stahl 1990; Tobin 1987). A longer wait time has the following effects on students: 1) the length and correctness of responses increases, 2) more students participate, and 3) academic achievement on tests increases. Teachers’ behaviors also changed with a longer wait-time, in the following ways. The teachers’ questioning became more varied. They decreased the quantity and increased the quality of questions asked (i.e., teachers asked more questions that required critical thinking).

Stahl (1994) suggests that wait-time should be called “think-time”, as students and teacher both need time to process information. There is nothing magical about waiting three to five seconds. What is important is that teachers and students have time to think. Teachers should facilitate discussions so that both they and their students have ample “think-time” before responding to questions. Teachers who practice using the “think-time” approach will improve both learning and critical thinking skills in their classrooms. Students are more likely to generate their own questions 1) if given the needed time, and 2) if taught how to formulate their own questions.
Teachers in the past have been the keepers of knowledge. However, many teachers do not realize that they do not have to know all the answers. What teachers need is the techniques and methods that enable them to help students construct knowledge by working in partnership with their students. “Reciprocal questioning” is a technique developed by Palincsar and Brown (1984) in which students take turns asking each other questions. The concept that communication with others helps learners construct their own knowledge stems from the theory of Vygotsky (1978), who maintains that learning occurs when an individual’s prior knowledge is reconstructed due to external social experiences. Teachers who use small group discussions allow their students to hear others’ point of view. Social interaction may foster learning when students have the opportunity to work out conflicting ideas (Roth & Roychoudhury, 1993). However, many students may not have the skills they need to work effectively with others. Also, the formal social structure of traditional science classrooms does not foster students’ working with others.

Methodologies for students working together have been developed called “cooperative learning strategies”. These provide structures for students to develop needed social skills (Johnson & Johnson, 1975; Kagan, 1994). When cooperative learning structures are used, students learn respect for a plurality of ideas and viewpoints. For example, teachers can use cooperative learning structures called think-pair-share. First the teacher asks a question. After students are given time to think, they pair up with another student and share their answers. Student pairs then share their answers with the class.

When students use inquiry to try and understand the natural world, there is a distinct possibility that the teacher might not have the required in-depth knowledge needed to facilitate an investigation. Not knowing the answer is acceptable from an educational perspective. However, the reality is that this is
not acceptable in classrooms structures where the teacher is the ultimate authority. The teacher's role in the classroom needs to encompass being an authority, a facilitator, and co-collaborator, allowing inquiry to occur. Many teachers may find this role difficult because they are unfamiliar with this approach. Also, students may need training in the skills required for inquiry-based learning.

When teachers ask open questions (questions with more than one acceptable answer), students must think of their own ideas. This may be new to some students who are used to giving the "one correct" answer. Students may feel insecure about coming up with their own ideas. Also, teachers need to become comfortable asking open-ended questions. These are questions that allow divergent thinking which can lead teachers and students to many different inquiry-based activities. Also, open-ended questions permit students to come up with alternative ideas.

Inquiry-based learning includes opportunities for the use of what Howard Gardner (1993) calls "multiple intelligences" or different ways of knowing such as: linguistic, logical-mathematical, spatial, musical, bodily-kinesthetic, interpersonal, and intrapersonal intelligences. Different students have different intellectual profiles. Inquiry-based learning is about students using their own individual intelligence in a real life context. The inquiry approach also allows for the use of interdisciplinary skills and knowledge. This is how things are in the real world. Traditional science teaching methods have students working in one discipline or subject at a time. Students in traditional classrooms often do not see how this compartmentalized educational system fits their personal lives. They often drop out of school, saying it is irrelevant. Applying skills using an inquiry-based approach makes students' work more relevant to their lives. This approach fosters intellectual curiosity and promotes the pleasure of learning.
Developing Students' Self-Questioning Skills

Many researchers agree that questioning is a skill that students should be taught in order to enable them to ask their own questions (Smith, 1973; Andre and Anderson, 1978-1979; Mcfeely, 1984). This is especially true when years of schooling has stifled students' natural curiosity. However, it is encouraging to know that studies have shown that students at all levels of education can be taught how to ask their own questions (Gillespie, 1990).

Student-generated questions encourage students to adopt a deeper approach to learning. Students become active participants instead of passive learners. They take more initiative for their own learning. Self-questioning skills lead to more meaningful learning and develop metacognition. Through self-questioning, students decide what strategies to use. Metacognition requires that the learners have awareness and knowledge of their own learning processes (Flavell, 1976). Metacognition and self-questioning both require the same skills.

What methods can teachers can use to increase the amount and quality of questions students ask? Pizzini & Shepardson (1991) found that student-to-student questions, and the frequency of student questions, increased during small group discussions after the teachers used the problem solving instructional model Search, Solve, Create, and Share (SSCS) for one year in their science classes. In the search phase, students generate questions. During the solve phase, students prepare their plan of action. The create phase involves designing a means to communicate their results with others. The share phase involves presenting results to others.

Perhaps the SSCS model's results are due to the fact that student questioning is an inherent part of problem solving and inquiry-based learning. Also, it is possible that over time these students became more experienced in
questioning. If the goal of science instruction is to create an environment that fosters student questioning, then the SSCS model may be a useful tool for teachers.

Gardner and Alexander (1982) had college students formulate their own questions during reading. They found that students performed significantly better when answering textually explicit questions after reading an article. Perhaps this advanced schema helps students with their comprehension. This schema may be what accounts for their improved scores. Weaver (1988) states that the goal of teaching should be to help students ask their own questions, which activates their own schemes. Then students should be allowed to search for their own answers with support from their teachers.

Marazano, Brandt, Hughes, Jones, Preseissen, Rankin & Suhor (1988) found that students become actively involved when they are allowed to formulate and ask their own questions. Students who generate their own questions become independent learners (Moore, Readence & Rickelman, 1989). Teachers can help students learn how to ask questions by modeling questioning strategies. By modeling, they are providing their students with a type of scaffold. Rosenshine & Meister describe these cognitive strategies in the following statement:

Scaffolds are forms of support provided by the teacher (or another student) to help students bridge the gap between their current abilities and the intended goal. Scaffolds may be tools, such as cue cards, or techniques, such as teacher modeling....scaffolds are particularly useful...for teaching higher cognitive strategies, where many of the steps or procedures necessary to carry out these strategies cannot be specified. [1992, p.26]

Teachers support students as they learn new skills. Scaffolds are only needed until students gain competence. As students gain skills, the teacher’s
involvement decreases and the student's responsibility for learning increases. This is a change in the teacher's role from that of an authority to a facilitator or co-collaborator.

From my review of the literature cited above, I recognize that students are more interested in their own questions than teachers' questions. Therefore, curriculum should evolve from students' questions and interests. Inquiry-based learning in the classroom requires students who can ask their own questions and work with one another. Yet, simply putting students into groups usually results in students' merely sharing and taking turns. However, cooperative learning strategies result in more productive learning together. Helping students learn how to work in groups is crucial to the success of an inquiry-based approach.

**Collaborative Learning**

The nature of scientific inquiry is collaborative. Scientists work mostly in groups and less often as isolated investigators. This is demonstrated by looking at the number of authors of most articles in scientific journals. The collaborative nature of scientific work should be supported in science classrooms through frequent student group work. Students should experience learning with one another instead of working alone. It is essential that students experience the process of coming to mutual understandings through group work, just like real scientists, as they carry out inquiry-based science activities. In *Science for All Americans*, written by the Association for the Advancement of Science, effective teaching and learning in science is described in the following manner,

...students should gain experience sharing responsibility for learning with each other. In the process of coming to common understandings, students in a group must frequently inform each other about procedures and meanings, argue
over findings, and assess how the task is progressing. In the context of team responsibility, feedback and communication become more realistic and of a character very different from the usual individualistic textbook-homework-recitation approach. [1990, p. 189]

Group work in science classrooms must be more than teachers merely splitting students into groups of three or four to carry out an investigation. Teachers need to explain how students are expected to work with other students. Furthermore, Ostlund (1992) says, "If we expect students to work together, we must teach them social skills just as purposefully and precisely as we teach them academic skills" (p.31). Cooperative learning structures are a methodology teachers can use to help students develop the social skills needed for group work.

For example, in cooperative learning structures called "group investigations" the students determine what questions to investigate and how to carry out the inquiry (Kagan, 1994). Students have control over their learning. They are allowed to investigate what interests them and to work collaboratively. All group members are involved both in planning how they will research the topic and in dividing the work amongst themselves. Each member carries out part of the inquiry. The group then analyzes and evaluates the work and presents their findings to the rest of the class. The teacher's role is to support students and help facilitate learning. The primary difference between simple group work and cooperative group work is that in cooperative groups, collaborative skills are emphasized, and peer learning is valued.

When students use cooperative learning structures, they learn important social skills that enable them to communicate appropriately with a diversity of other learners. Cooperative learning structures help students learn how to listen to others' ideas. When students work with others, using cooperative
learning structures, they learn to voice their own opinions and share information. Johnson and Johnson (1984, 1987) assert that students who work in cooperative learning structures exhibit greater competence and critical thinking skills.

Cooperative learning structures help students accept differences and appreciate that everyone has something valuable to contribute to the group. Cooperative learning structures create opportunities for interpersonal contact. Spencer Kagan (1994) has found that one outcome of using cooperative learning structures is closer relationships among students. These teaching structures promote teamwork among students. These structures also create an environment where teachers are more positive and enthusiastic, and where students can be actively engaged in inquiry-based learning.

Sharon & Sharon (1992) have found that cooperative learning structures have positive effects on the interaction and relationships between students from different ethnic groups in heterogeneous classrooms. This is important in today's classrooms because the 1994 U. S. Bureau of the Census school enrollment Figures for grades 1-12 shows that roughly thirty percent of students were African-American, Hispanic, or other races. We need to create a sense of safety in the classroom, where all students are treated with dignity and respect. Each classroom should be a community of learners that have a shared purpose, allowing diverse individuals to participate. We need to start where our students are and move forward with them, as they voice their personal feelings and experiences. Our goal should be to expose students to diverse perspectives that require them to think critically and analyze information. These are the skills needed to actively participate in a democratic society. These are also the skills that are developed in an inquiry-based science curriculum, or authentic science.
Cooperative learning structures promote personal acceptance and constructive verbal communication skills that are necessary when students participate in collaborative inquiry-based learning in heterogeneous classrooms. Cooperative learning structures also improve students' self-esteem. These structures change the locus of control, to become more internal, and help students feel success is due in large part to their own efforts. Students who believe their behavior is responsible for their success in school have what is referred to as an internal "locus of control" (Banks, 1988). When students have an internal locus of control, they are more likely to be successful academically. Time on task increases, liking classmates and feeling liked by classmates increases. There is more cooperation and the ability to take another's perspective. The teacher feels less need to control the class and students' behavior when cooperative learning structures are used (Kagan, 1994). Cooperative learning structures help the teachers' role change from one of authority to a facilitator or co-collaborator, which is needed for inquiry-based learning to occur.

Many studies have found that inquiry-based learning encourages social interaction. This type of learning enhances formal reasoning skills (Hall & etal, 1989; Karplus, 1977; Lawson, Norland, & Devito, 1975; Renner & Lawson, 1980). Cooperative learning structures also foster social interactions. Garton (1992) believes that social interaction is needed for cognitive development. He says that without social interaction students would not be able to learn, to understand, or to know. Social interaction involves cooperation among students. Understanding is more likely to occur when students have to explain or defend their position to others (Brown and Campione, 1986). Cooperative learning structures can be used that require the exchange of ideas, such as *rally robin* (Kagan, 1994) in which students form pairs within a team of four and
take turns with their partner sharing ideas back and forth. Then, the pairs share their ideas with their team. Students benefit from exposure to different perspectives.

In summary, collaboration with others enhances students’ understanding. Students’ critical thinking skills improve from working with others. Educators have discovered that cooperative learning structures improve both students’ social skills and their academic skills, such as communication, interaction, cooperative planning, sharing of ideas, decision making, listening, taking turns, and exchanging and synthesizing ideas. I believe that science classrooms that use both inquiry-based activities and cooperative learning structures are environments where students learn to actively participate in a community of learners. In such a classroom, students feel safe to express themselves because all questions and responses are accepted and respected.

**Toward Improved Assessment**

School science curricula have undergone substantial changes in the last thirty-five years, yet assessment techniques have not made much progress. There is a need to align student assessment with student understanding and other desired learning outcomes. Assessment should permit students to demonstrate their skills and knowledge in the context of solving a complex problem. Assessment of student performance is critical to the ongoing improvement of school science.

What is meant by assessment? Hein has defined it as follows:

Assessments are judgments.... In education, assessment refers to evaluation of educational outcomes.... All attempts at assessment require definitions.... What exactly is it that we are assessing? What are the criteria? What methods can we use? What evidence is available? Who is doing the assessment, and what are the qualifications of that person?
What are the consequences of the assessment? Who gains or loses? [1990, p. 1]

Today's teachers often use assessment tools that only require the memorization of facts. Yet they complain about the lack of critical thinking in their classrooms. Tests (i.e., instruments used to measure student learning) are still the most common form of assessment used in education. Tests are traditionally given after students have been exposed to material and presumably have learned it (Hein & Price, 1994). Tests are usually pencil and paper exercises carried out silently and individually. Students are judged by a single numerical score that tells them very little about their current level of progress and gives them no help in improving.

Testing influences what is taught in school districts. In many classrooms factual knowledge continues to receive more attention than the espoused goal of critical thinking. The 1985-1986 Nationwide Survey of Science and Mathematics Education, conducted by Iris Weiss (1987), has shown that science is not allocated much time in a large percentage of our nation's elementary schools. Weiss reported that teachers of grades 1 through 3 spend 19 minutes a day on science, while teachers of grades 4 through 6 provide an average of 38 minutes a day on science, with lectures and discussions making up more than three-fourths of that time. This is not surprising when we see that standardized test in elementary science only appear at certain grade levels, usually grade 3 or 4. Elementary teachers emphasize "the basics" (reading, writing, and math) that are tested, leaving very little time for science instruction. Even when science achievement is tested, Raizen (1989) asserts that nationally normed science achievement tests do not measure process skills and critical thinking skills. Unfortunately, traditional testing shows us how little educators
respect science process skills and critical thinking skills, which are harder to measure by pencil and paper test.

All students need to learn a certain amount of factual material in order to be able to do science effectively. However inquiry-based learning emphasizes science process skills and critical thinking skills. Hein (1990) writes about the inconsistency in what science teachers try to teach and what they try to measure. Today's science educators want students to learn science using an inquiry-based approach. Therefore it is essential that the assessment techniques be consistent. They must require students to demonstrate their science process skills and critical thinking skills. They must also measure subject matter learned. Hence, there is a need for the development of alternatives to standardized and norm-referenced tests. These alternatives would be more consistent with an inquiry-based approach.

The challenge is to document students' achievement, using multiple and varied methods. These may include tests. The varied methods should be easily done by teachers and helpful to the students. Using different methods of assessment increases the opportunity for every student to demonstrate their understanding. It also provides the teacher with multiple opportunities to note cultural or racial differences that may affect a teacher's judgment of a student's performance (Hein & Price, 1994). Assessments that allow multiple ways for students to respond would be less biased.

Grant Wiggins (1993) argues that assessment should be designed to help improve students' performance, not just monitor it. Assessment should start conversations between the teacher and student about performance, instead of ending them. The purpose of assessment should be to assist and inform the learner. Teachers should give feedback to students, and together decide where to go next, based on their assessment.
Many terms have been used to describe the new assessment strategies, such as alternative assessment, active assessment, authentic assessment, and performance assessment. All of these terms refer to assessment of what students can do, based on their knowledge. When teachers use these new assessment techniques, they no longer regard assessment as the end product of learning.

Educators need to consider alternative forms of assessment that are more compatible with an inquiry-based approach in which students seek answers to their own questions. Assessment has traditionally been used to measure the level of achievement of desired outcomes. However, the goals of inquiry-based instruction go beyond memorization of facts and information. Inquiry-based learning emphasizes science process skills and problem solving skills that require critical thinking. These goals are ignored by multiple-choice tests. The outcomes of inquiry-based learning and indicators of those outcomes can only be assessed by “active” assessment, a label for a variety of assessment methods in which the learner is actively engaged (Hein & Price, 1994). Active assessment demonstrates the acquisition of knowledge, concepts, and process skills, and the ability to apply them in new situations.

Traditional multiple choice tests impede the implementation of inquiry-based approaches in science education. It is easy to test for the memorization of facts. It is much more difficult to measure knowledge derived from inquiry-based learning. Alternative methods of assessment must be developed that encourage an inquiry-based approach.

**Assessment Methods**

- **Performance based assessment:** Students are allowed to demonstrate their science process skills and understanding as they work on solving
problems. This allows the teacher to see how students go about solving a problem. Teachers who use this assessment method can assess what ideas or concepts students are learning from an activity, as well as students’ ability to use science processes and skills. Teachers gather information about students through observing, listening, and asking questions. Some refer to this as embedded assessment (Shavelson & Baxter, 1992; Silverstein, 1993). Students may be assessed individually or in groups. Group assessment allows the teacher to assess students’ cooperative group skills.

Scoring rubrics that stress conceptual understanding, critical thinking processes, communication skills, and content knowledge need to be developed before the assessment and shared with students. Establishing scoring rubrics in advance helps ensure that teachers are fair, consistent, and unbiased in their judgment of student work. When rubrics are used students can be graded on each section, as well as their whole work. Using this approach allows students to can obtain in-depth information on their achievement in addition to their total scores.

• **Student’s self evaluation:** Teachers can support student self assessment by identifying the criteria (scoring rubrics) by which students will be evaluated. Clearly established criteria enable students to better understand the characteristics of good performance (Fredriksen & Collins, 1989). This technique encourages self-reflection. When students evaluate their own progress, they identify their own strengths while diagnosing weaknesses. Self-assessment empowers students to become responsible for their own learning. Taking responsibility for learning helps students build life long learning strategies.
• **Portfolios**: These are selections of individual students' work that contain evidence of achievement. The portfolio should represent both the students' work and progress of a student over time. This might include the teacher's systematic observations focused on specific tasks, such as a students' understanding of scientific concepts, science process skills and scientific attitude. It might include student-created work such as journal notes, lab reports, drawings, videotapes, computer discs, and project descriptions. The teacher and student decide together what should go into this collection. Having students select items for this collection encourages them to take ownership of their work.

In general, assessment should reflect what students can do with knowledge, not how well they can memorize facts. The goal of active assessment is to provide teachers with information about students' understandings, skills and knowledge. The focus on science process skills and conceptual understanding encourages the development of critical thinkers and effective problem solvers. While some assessment issues can be addressed by teachers in their own classrooms, changes also need to occur at the school district, state, and national levels. This will require support from the different communities if it is to be successful. School systems and communities must work together to decide what the purpose of assessment is and how it can be most effectively accomplished.

In conclusion, assessment is a powerful tool for invoking change in science instruction. It is true that science teaching that emphasizes factual information may produce students with higher academic achievement scores when the assessments are based on factual knowledge. However, assessment strategies based on science process skills and critical thinking skills will result
in science instruction that emphasizes science skills and the ability to use
science in one’s life. By focusing assessment schemes more clearly on the
desired outcomes of inquiry-based learning, educational leaders can help
change the way that science is taught in schools.

**Summary**

Science educational leaders have advocated for an inquiry-based
approach for the past 100 years. Yet inquiry-based learning, in science
classrooms, is less frequent than lectures and demonstrations. This may be
due in part to science teachers’ confusion over what inquiry-based learning is
suppose to look like in classrooms. Many teachers associate an inquiry-based
approach with the guided inquiry approach in which students are guided to
predetermined scientific concepts and than administered traditional written test.
As a result, most laboratory experiments remain cookbook activities designed to
verify scientific laws or principles. The reality is that facts and scientific
information continue to receive more attention than student engagement in
“authentic” science.

Today’s challenge in science education is implementation of an inquiry
approach that is more than cookbook and verification labs. I believe that
another reason that inquiry-based learning has not been incorporated in
classrooms may be that teachers are inexperienced with inquiry-based
learning. In order for them to truly understand this approach present and future
teachers need to experience inquiry-based learning in three areas of their
development: 1) science courses they take as students, 2) in science methods
courses they take while preparing to become teachers, and 3) in inservice
workshops they take once they are certified teachers.
In today’s science classrooms, students need the freedom to pursue problems of their own interest, which are personally relevant, in a supportive collaborative environment. Educational leaders generally agree that science teachers should use a constructivist pedagogy in which students participate in inquiry-based learning that challenges them to construct meaning out of their experiences. Furthermore, science educators are aware that student learning can be enhanced through collaboration with others. Learning is promoted when students talk with others about their understanding and experiences. Science teachers using an inquiry-based approach can use “cooperative learning structures” to help students learn how to effectively work with others.

Teachers can also scaffold students’ understanding of inquiry-based learning by making them aware of the processes they are using as they conduct an inquiry. Overall, in order for an inquiry-based approach to be successfully implemented, students must be encouraged to ask and solve their own questions in collaboration with others (just like real scientists). Also, assessment methods must be more consistent and require students to demonstrate their critical thinking skills as they actively conduct inquiries.

As students’ ability to use the inquiry approach expands, they should be given more opportunities to conduct independent inquiry. The goal of science education should be to lead students to independent inquiry. When students actively engage in independent inquiry they are able to truly comprehend “authentic” science. After all, as Hodson (1988) stated “science is open-ended project work, in which the content and the methods, as well as the outcomes, are largely unknown at the outset” (p. 65). The only way to understand science is to do science.
CHAPTER III

THE STUDY

Nature and Design of the Study

The reasons for gathering data and the type of data collected exemplify the two major paradigms in educational research, often referred to as quantitative and qualitative inquiry (Borg & Gall, 1989). In general “what” and “how many” types of questions are best answered by quantitative inquiry, whereas “how” or “why” questions are best answered by qualitative inquiry (Yin, 1994; Marshall & Rossman, 1995). Quantitative methods are advantageous when the research goal is to describe the prevalence of a phenomenon (Yin, 1994). However, if I needs to know “how” or “why” a program worked (or not) the researcher should use the qualitative case study method. Today many researchers argue for the use of a combination of qualitative and quantitative methods; they maintain that this combination is superior to either alone (Brewer & Hunter, 1989; Reichardt & Rallis, 1994).

In this study, all students who participated in the SSEP, who could currently be contacted, were used in the program evaluation. This lowered the chance of random or sampling error (the probability that, if a different sample of the same size were drawn from the population, different results might have been obtained). Random error is the unpredictable error that exists in all research (Litwin, 1995). Yet, this type of error can be lowered by selecting a larger and more representative sample. However, random error is the smallest of three types of error which can affect the validity of the sample designs. Two
other types of errors - sample bias, and response bias - are much more likely to jeopardize the validity of the findings (National Science Foundation (NSF), 1993). Sample bias occurs because selected respondents are not available or refuse to participate. A remedy for this type is error is for the researcher to repeatedly attempt to reach the non-respondents. Response bias can occur when respondents misunderstand questions or fail to give an honest opinion (for example, they may deliberately mislead to protect the project being evaluated). Pretesting survey instruments can help reduce misunderstood questions. In personal interviews, the effect of misunderstood questions can be remedied by conducting a pilot study and revising the interview questions. There is no remedy for respondents not telling the truth in self-administered surveys; however when conducting interviews this type of error can be reduced by a capable interviewer.

There were two levels of participation to the SSEP evaluation, with the second level building on the first. The levels differed in the amount of data collected and in the data collection methods used. However, the two levels of evaluation combined to offer a rich blend of quantitative and qualitative information which helped our understanding of the long term impact of inquiry-based learning in science and more specifically of the SSEP.

**Quantitative Methods**

Surveys are a popular tool for program evaluation. They are useful for obtaining information about opinions and attitudes. The findings lend themselves to quantitative analysis; the results can easily be stated as percentages or means. In comparison to other methods of data collection, surveys are wider ranging but less detailed and may be biased if the participants are not truthful. However, surveys are relatively inexpensive to
administer and easy to analyze due to the availability of statistical software. Therefore, surveys are an appropriate tool to identify students' attitude towards science and interest in scientific careers when one desires the answer to the question "how many". (For example, "How many SSEP students changed their attitude towards science because of their experience in the program?"

In impact studies, the researcher is measuring change over time. This requires a minimum of two measurements: baseline (at the project initiation) and later when the program has allowed enough time for change to occur. Quantitative studies which use data collected from the same population at different points in time are referred to as "longitudinal studies". However, designs that require locating the same participants are often difficult to carry out because participants move. In addition, longitudinal studies require that identical survey instruments be used at all times. Any changes in the surveys could impair the validity of the evaluation.

**Survey Prior to the Summer Science Exploration Program**

Two quantitative surveys, the *Science Opinion Survey* and the *Career Decision-Making Revised Survey* (see appendix A) were administered to students prior to their participation in SSEP. [In addition, students were asked to fill out an information sheet which asked them for their initials, date of birth, ethnicity and grade (see appendix A)]. The surveys were used to determine students' attitude towards science and interest in scientific careers. For comparative purposes, surveys along with the student information sheet were also administered in 1992, 1993 and 1994 to similar groups of students, in Holyoke and Chicopee, who did not attend the SSEP. While the non-equivalency of the groups reduces the overall degree to which group differences can be attributed to the SSEP, they do represent real differences
present among these schools and allow for a comparison of pre and post test results.

**Longitudinal Follow-Up**

The same two surveys were again administered to the SSEP participants. The pre- and post-surveys could be matched due to information in the database about the participants. This repeated measurement technique (pre and post) provided me with measures of change over time. In the Spring of 1997 schools in Chicopee and Holyoke administered the surveys, as well as the student information sheet, to similar students who did not participate in the program. This offered a group of students from the same schools with which students who went to the SSEP could be compared. In addition, students who applied to the program but were not selected to participate were located and filled out the surveys and the student information sheet. This group of students represents a quasi-control group, because the students who were selected to participate in the program were randomly selected from the pool of applicants.

**Survey Instruments**

The Science Opinion Survey produced by the National Association for Educational Progress is a 30 item questionnaire, developed at Florida State University. It assesses current interest and attitudes in science activities at school. Students use a five point scale (Strongly Agree, Agree, Not Sure, Disagree, Strongly Disagree) to rate statements about science activities. Responses are scored from -2 to 2 with statements coded so that positive scores indicate interest in science.

Questionnaires are checked for internal consistency using eight pairs of antonym items (e.g., *Science lessons are fun.* vs. *Science lessons bore me.*)
Internal consistency indicates how well different items measure the same issue. Responses from the item pairs are compared and differences totaled. Students whose differences scores are two standard deviations above or below the sample are excluded due to the lack of internal consistency on their surveys.

In the pre-SSEP surveys of the 157 students who participated only six students’ results were excluded due to lack of internal validity. This demonstrates that this survey instrument has a very high internal consistency reliability. All survey instruments, even established survey instruments, should be tested on groups that have not been previously tested to document the survey’s reliability (Litwin, 1995). Reliability provides quantitative measurement of how well an instrument performs with a given population.

**Career Decision-Making System Revised (CDM-R)** was developed by Thomas F. Harrington and Arthur J. O’Shea (1992). The CDM-R is a comprehensive career interest survey. Students rate the likes and dislikes on 96 questionnaire items that describe career activities (e.g., *Be a judge or Teach and help people in poor countries*) using a three point rating scale (like, not sure, dislike). The items are totaled for six different career interest areas: business, art, social, science, craft, and office. Scores from these six areas are rank ordered.

**Qualitative Methods**

Qualitative case studies are one of several methods of doing social science research. The particular strength of the case studies method is the unique ability to deal with a full variety of evidence, such as documents, artifacts, interviews, and observations (Yin, 1994). Qualitative researchers agree that multiple sources, multiple data collecting methods, and pattern
matching from multiple sources add validity to the case study (Denzin, 1978; Jick, 1983; Yin, 1994; Patton, 1990; Kidder & Fine, 1987). An advantage of qualitative data is that it can provide in-depth understanding of key elements of a program which contribute to the success or failure of that program (Yin, 1994).

Different research strategies each have their own advantages and disadvantages. While case studies are an accepted form of inquiry, many research investigators still have reservations about this methodology. Too often, some complain, the case study investigator has allowed personal biases to influence the findings (Yin, 1994; Rosenthal, 1966). Therefore case study investigators must make every effort to report all evidence fairly. Another concern raised is about generalizing the findings. Scientific experiments are repeated many times before reaching conclusions that are then generalizable to populations. However, one must realize that case studies are not generalizable to populations, but only generalizable to theories (Yin, 1994). The case study does not represent a sample and the researchers’ goal is not to calculate frequencies; instead the goal is to improve and generalize theories.

In this study, case studies yielded a wealth of additional information regarding the long term impacts of the SSEP. In addition, case studies addressed the broader research interest of the long term impact of inquiry-based learning in science classrooms on students’ attitude towards science. Case studies offered particularly detailed insights into students’ attitude towards science and interest in science. Case studies also helped identify other influences on students’ attitude towards science and interest in science.
The Interview Protocol

In this study, semi-structured interviews were used. Using semi-structured interviews allowed me to be flexible and adapt the questions to each particular interview session. With a list of topics to cover and suggested questions I introduced the topics of conversation and through questions steered the course of the interview. Yet, at the same time I was flexible and changed the order of topics and forms of questions in response to the answers given by the interviewee.

The objective of the interviews was to address the primary research questions. Pertinent topics to discuss were established to help develop interview questions that contributed to answering the evaluation questions as well as promoting a good exchange between myself and the interviewee. Three areas of interest were: (1) students' academic life, (2) students' science education, and (3) students' experience at the Summer Science Exploration Program at Hampshire College.

I developed questions, in the section on students' academic life, to set the students at ease, to allow students to talk freely, and share their feelings and opinions with me. Some questions were designed to find out if any other external factors affect students' attitudes towards a subject. Other questions were created to learn about students' career plans after high school. In the second section, on students' previous science education, the objectives were to find out what science courses students had taken, as well as to uncover their feelings about various experiences in different science classrooms. Again, in this section, some questions were developed to gather information about other external factors that might affect their attitude toward science and career decisions. In the last section, about the Summer Science Exploration Program, questions were designed to learn about the students' perspective about their
summer camp experience. In addition, questions were developed to learn about the impact of the program on their lives.

**Interview Procedures**

Before conducting interviews with students, I explained the purpose of the study and received written consent from students and parents (see appendix B). The interviews were audio recorded and later transcribed. Interview transcripts were completed, dated, and stored both on disk and in a separate folder. The interviews lasted from one to two hours. As data was collected, all important information was stored in folders under the interviewee's name. Each folder included (1) field notes, (2) student interview transcripts, (3) student survey reports, and (4) miscellaneous information that could prove useful.

**Interview Guide**

Following is the list of questions I referred to while conducting the interviews.

**Academic Life**

• What's your favorite school subject? Why?
• What’s the teacher in your favorite subject like?
• Do you think it's the teacher, the subject, or the way the subject is taught that affects your attitude the most?
• How does attitude towards a subject affect learning that subject?
• Are there subjects you don’t like in school? If so, why?
• What do you do best and worst in at school and why do you think this is so?
• Do you like school? Why or why not?
• In general what do you like and dislike about school?
• What are your career plans after high school?
• (If they plan on going to college) What do you plan to major in at college?
Science Education

• What science courses have you taken in high school? Tell me about these courses? How were they?
• Did you take more than the required amount of science courses in high school? If so, why? What additional courses did you take?
• Did you have science in elementary and middle school?
• Tell me about elementary and middle school science.
• Was science in elementary and middle school the same or different as high school science?
• How do you feel about science in general and explain why?
• Tell me about any good and or bad experiences in science that you have had.
• When did you start feeling good or bad about science? Explain.
• What affects your attitude towards science the most?
• What were your science teachers like?
• Have all of your science teachers been similar or different?
• Have your science teachers been men or women?
• (If going to college) Do you plan on taking more science courses in college? If so, why?
• Have you participated in any other programs related to science? If so, explain.
• Are any members of your family in science related careers? If so, which ones?
• How do you think science should be taught?
• How would you change science education?
• What were your science classrooms like? Describe the rooms and equipment.
• Did you do many hands-on activities in science? About how often?
• Describe your typical science class.
• If you could study anything you wanted in science, what would that be?

The Summer Science Exploration Program at Hampshire College

• Tell me about your experience at Hampshire College.
• Describe how the summer program was like or different from science at your school.
• (If they talk about how different it was then ask them) Which method of science instruction do you prefer and why?
• How did the summer program affect your attitude towards science?
• How did the experience at Hampshire College affect you?
• How did your experience at Hampshire College affect how you did in school after the program?
• What were the advantages of attending the SSEP at Hampshire College?
• What would you say to other kids who were thinking about going to a program like this?

Levels of Evaluation

I attempted to contact all 157 students who participated in the Summer Science Exploration Program (SSEP). All students were asked if they were willing to be interviewed and to fill out the two survey instruments. From this information, two groups were created. The first group contained students willing to both be interviewed and fill out the surveys. A second group contained students who are only willing to fill out the surveys.

All of the students not chosen for interviews were mailed the surveys. The surveys were mailed to their home address, with a postage paid addressed envelopes for them to return the surveys. In addition, the surveys were coded to allow me to compare student responses with the surveys they filled out on the first day of the program. Students who had not responded two weeks after the second mailing were contacted via telephone when possible.

Level I

Students in this level were asked to fill out the two survey instruments. The two instruments took about 15-20 minutes for students to complete. This level of evaluation provided important information about whether there was any change over time in SSEP students' attitude towards science and interest in scientific careers.
Level II

Twenty-two students were selected for qualitative case studies. Case studies of student participants of the SSEP included the following multiple sources of information: the pre and post Science Opinion Surveys, the pre and post Career Decision-Making Revised (CDM-R) Surveys, information in the database on students’ gender, ethnicity, age, grade, and geographic location, and transcripts from interviews.

In most current interview studies, the number of interviews selected is around 15 +/- 10 (Kvale, 1996). The goal is to obtain in-depth information from a few case studies. Qualitative case studies emphasize quality of data rather than quantity of cases.

The following criteria and procedures were used to determine which students would be included in Level II of the evaluation: (1) Students willing to be interviewed were divided into groups by ethnicity and gender. The following groups were included: white females, white males, African American females, African American males, Hispanic females, Hispanic males, Asian American females, Asian American males, and others. Students willing to be interviewed were stratified into the above groupings, and then participants in each grouping were randomly selected. (2) A representative sample that reflected the ethnicity and gender of the population that attended the SSEP was selected (see appendix C). For example, 26.1 % of the SSEP participants were white females, therefore approximately 26% of the students chosen for interviews were white females, etc.
**Data Analysis**

The extent to which the Summer Science Exploration Program (SSEP) affected students' attitude towards science and interest in scientific careers was determined by the triangulation of the data collected by the two methods of evaluation research.

The first method of evaluation was interviews with a selected representative group of students. Qualitative data was collected from the interviews. Items included in the interviews explored both students' school and science education experiences. In addition, students were asked to reflect about their experiences at the summer science camp. Students' interest in science and scientific careers were explored, as well as any unexpected issues that emerged during the interviews. Additionally, this analysis considered the possible importance of other external events on students' interest in science and scientific careers.

The resulting data from the interviews were coded using HyperRESEARCH (ResearchWare, 1994) a content analysis tool designed for the qualitative researcher. This computer software was used to identify commonalities, and draw generalizations (Borg & Gall, 1989). This categorization or coding of students' responses provided information for judging how typical a response was.

The second method of evaluation was by surveys administered to all of the SSEP participants, students who applied to the program but were not accepted, and to a similar group of peers from the same school. The objective of the surveys was to determine whether students' attitudes towards science and interest in scientific careers changed as a result of participation in the program. I compiled the data and analyzed it using Statview, version 4.5.
Analyses of Variance (ANOVAs) and t-tests were run to test for statistically significant differences among the groups.

Interview and survey data were compared to provide an understanding of the Summer Science Exploration Program so that generalizations could be made about the effect of participation in the SSEP on students' attitudes towards science and interest in scientific careers, as well as identifying the aspects of the program which encouraged those changes.

**Pilot Study**

A pilot study was conducted in the Spring of 1996 to field test the research design and methodology. Because the overall goal of the study was to find out if the SSEP had any long term impact on students' attitude towards science and career choices, I decided to interview students who participated in the SSEP during the first year of the project. (Pilot study cases may be selected for reasons different from the criteria for selecting the final cases in the case study design.) During the summer of 1992, 56 students attended the SSEP at Hampshire College. Eighth grade students who participated during the first year of the grant period were contacted and recruited for interviews. They were juniors in high school during the spring of 1996, when the interviews were conducted. I felt that this group of students would be the most likely to be considering career decisions, since they only had one more year of high school.

Of the 56 students who attended the SSEP in 1992, seventeen were in eighth grade that year. This was the target group for this pilot study. Students during the first year were all from the urban communities of Springfield and Holyoke. Using information in the database I attempted to call each one of these students. I was able to locate only three students using this method, as only three out of the seventeen students still had the same telephone numbers.
It is interesting that all three students who were contacted were willing to be interviewed and to fill out the surveys. The rest of the students' telephone numbers had either been disconnected or were wrong numbers. This is not surprising when one looks at the statistics concerning mobility in American society: about one-fifth of all Americans relocate every year; furthermore in a typical inner-city school, only about half the students who start school in September are still at the same school at the end of that school year (Hirsch, 1996). The Massachusetts Department of Education’s projected 4-year dropout rates are 42% for Springfield and 33% for Holyoke (based on students in the class of 1998). The projected four-year dropout rate is determined by calculating the cumulative effect of several years of dropping out. Using the above statistics one might estimate that up to 50% of the students had relocated or dropped out of school. Another possible explanation is that poor inner-city families may have their phones disconnected due to the lack of ability to pay their telephone bills.

As Kvale (1996) says, “Learning to become an interviewer takes place through interviewing” (p.147). I went back to the list and called seventh grade students. I was able to locate four more students using telephone numbers in the database. These additional students agreed to be interviewed and fill out the surveys. Conducting additional pilot interviews with diverse students gave me more practice with my interviewing skills.

From this experience, I learned that it was difficult to locate students after three or four years. However, it was very encouraging to find that, when I explained the project, every student located was willing to participate in the interviews and fill out the surveys. Further, I learned that in order to obtain a representative sample of students from the population that participated in the
SSEP, for the final case studies, I may have to track down students using other methods, such as contacting local schools, community groups, etc.

In addition, two important logistical questions were: 1) Would students allow me to conduct interviews in their homes? and 2) Could the surveys be used in a one-on-one situation? In answer to the first question, I discovered that all seven students were willing to be interviewed in their homes. The second concern arose because in the past the surveys had been administered to groups of students at Hampshire College on the first day of summer camp. The National Science Foundation's, *User-Friendly Handbook of Project Evaluation* (1993) suggest that all instruments should be pre-tested to see if they work well under field conditions. Thus, they had never been used in this one-on-one fashion. I found that students were able to fill out the surveys without any difficulties after the directions were given.

Another concern was how suitable semi-structured interviews would be. Would I be able to get the desired information using this interview structure? From the pilot study, the researcher learned that some participants provided the sought after information without having to be asked many questions, whereas other participants needed more structured questions. Thus this format worked well with students. It allowed the researcher to structure the interviews differently for each interviewee.

In summary, the researcher improved the interview protocol as a result of conducting the pilot study. The researcher refined the interview questions, added more pertinent questions, and learned how to conduct interviews that would elicit information relevant to the primary evaluation questions being asked in this study.
Longitudinal Study

Locating the students who attended the SSEP was a challenging task. I had to locate students from Holyoke, Springfield and Chicopee who had gone to camp several years ago. It turned out that many students were no longer at the same address and telephone number that they were when they attended camp.

I started trying to locate SSEP students by calling all the students whom I had telephone numbers for to ask them if they were willing to participate in the study. SSEP students' telephone numbers and addresses were in the files. During the phone conversation with the students I asked them if they were willing to be interviewed. If they said yes, they were added to the "willing to be interviewed list", if they said no, I asked them if they were willing to fill out the surveys.

After spending several weekends and many evenings on the telephone I was able to contact 74 out of the 157 SSEP students. While this was encouraging I was still missing a large proportion of the Hispanic students who came to the program from Holyoke. This was a concern, because I wanted to get a representative sample that reflected the ethnicity of the population that attended the SSEP. So I decided to go out to the public schools and see if they could help me locate some of the missing students.

There were 35 SSEP students who lived in Holyoke that I still did not have telephone numbers for. I contacted Holyoke High School and asked them to help me locate these students. They asked me to come to the school to discuss the study and to bring the list of students I was looking for. While I sat and talked about the project with a school official, they had someone check the list against school records. They then provided me with the names of 12 SSEP students on the list that currently attended Holyoke High. In addition, they
provided the names of any students on the list who had moved out of city or dropped out of school. While they could not provide me with the students’ telephone numbers, they were willing to let me come into the school on another occasion and meet with the SSEP students who currently attended Holyoke High and pass out a letter which asked them to participate in the study (see appendix B). I met with only six students on the day we had arranged ahead of time because 6 students who attended were absent from school on that day. I talked to them about the project and passed out letters (see appendix B) and stamped self-addressed envelopes asking them to participate. The letters needed to be signed by a parent and then mailed back to Hampshire College. The school assured me that they would pass out the letters to the students who were absent. Three of the students that I met with returned the permission slips to participate. One indicated that they were willing to be interviewed and the other two indicated that they were only willing to fill out the surveys. None of the 6 absent students ever responded.

I contacted Dean Vocational High School in Holyoke to ask for their help locating the rest of the Holyoke students. I sent them a list of the students I was looking for and they told me that 11 of those students were currently enrolled in their school. I was not allowed to go to the school and meet with these students. They felt it was more appropriate that I write a letter to the students asking them if they were willing to participate in this study. I was assured that they would give this letter to the students at their school. The 11 students at Dean Vocational High School were all given letters (see appendix B) by the guidance counselor asking them to participate. None of the students ever returned the forms. Dean Vocational High School would not provide me with the names of the SSEP students who were currently attending their school. In addition, they would not provide me with any information about whether students moved,
dropped out, or were ever enrolled. However, they did (according to a guidance counselor) on two occasions give students letters explaining that I wanted to get in touch with them.

After all this effort I still had 32 SSEP students from Holyoke for whom I had no telephone numbers. What I had learned was that 11 students attended Dean Voc, 9 students attended Holyoke High, 3 students had dropped out of school, 1 student had moved out of city, and 11 students still could not be located (may have moved, gone to private school, or dropped out of school). I assumed at this point that the 20 students who currently attended Dean Voc and Holyoke High had decided not to participate in this follow up.

A list of 45 SSEP students I could not locate was sent out to Springfield and Chicopee schools. It contained 35 students from Springfield and 10 from Chicopee. In Chicopee I spoke and worked directly with the Superintendent of Schools. The Outreach Coordinator for Hampshire College had a contact in the Springfield schools, the Head of the Science Department. Collectively, these school systems provided me with the current telephone numbers for 24 students from Springfield and 8 students from Chicopee. I assumed that this meant that these 32 students still attended the local schools. The other 13 missing students may have moved out of city, gone to private school, or dropped out of school.

These 32 telephone numbers helped me locate only 13 students, all of whom were willing to participate in the survey and/or interviews. This was only 29 percent of the students that I had set out to find. Of the other 19 students’ telephone numbers seven had been disconnected, three were wrong numbers, two were not in service, one had changed to an unpublished number, and six did not answer after repeated attempts to call. What this demonstrated was that
even recent school records are not up to date with students' telephone numbers.

Overall, I was able to contact 70 percent of the SSEP students. In addition, 57 percent of these students were willing to participate in follow-up activities. I was unable to contact the other 30 percent of the SSEP students, which included 15 students from Holyoke, 25 students from Springfield, and 6 students from Chicopee.

Figure 3.1 gives the breakdown of the number of SSEP students contacted by telephone in each ethnic category. (The actual number of students in each ethnic category was based on student data collected during 1993 and 1994, whereas for 1992 estimates were used that were based on students' names and addresses, because during 1992 ethnic data was not gathered from students.)
Figure 3.1
Telephone Contact Rate

Key:  
# = Number  
w/f = white females, w/m = white males  
Af/f = African American females, Af/m = African American males  
H/f = Hispanic females, H/m = Hispanic males  
As/m = Asian American males, (no Asian American females attended)  
NA = Not Available or other

Figure 4.1 shows that I was only able to make telephone contact with a small fraction of the Hispanic students. The Hispanic students who participated in SSEP, most of whom were from Holyoke, were a difficult group of students to track longitudinally. However, I was fortunate that 70% of the Hispanic students with whom I made telephone contact agreed to participate in the interviews.

It is important to note that, when conducting longitudinal studies, talking to participants on the telephone seems to increase the chances that they will
participate in any follow-up activities. All SSEP students who were contacted by telephone said they were willing to complete the surveys; in addition 80% of these students said they were willing to be interviewed. The students who said they were only willing to do the surveys apologetically explained that they didn't have time for one of the following reasons: they were very busy with school, playing sports, in the school band, or they worked after school.

**Locating Students Who Applied But Were Not Accepted**

The students who applied to the program but were not accepted were used as a control group. To identify these students, I had to go through the SSEP files. Unfortunately, in 1992, no records were kept of these students. However, in 1993 and 1994, all students who were interested in attending the program were asked to write statements of what they wanted to gain and what they could bring to the program. They were also required to submit letters of recommendation (one per student) from teachers who knew their work and potential. These letters were used to contact this group of students. The letters contained the home address of 70 out of 106 of the students who applied but were not accepted. This was the group that I targeted.

I mailed a cover letter (Appendix B), the student information sheet, and the surveys out to these 70 students: 29 were returned completed, while 19 were returned undeliverable. After waiting several weeks a second mailing was sent to the 22 students I had not heard from. An additional 6 surveys were returned completed. Of the students who completed the surveys, 23 were white, 6 were Hispanic, and 6 were African American students. Of these students, 22 were females and 13 were males. Thus, this group clearly represented the same type of students who went to camp.
I looked to see if any of these students had participated in the surveys that were conducted in 1992-1994 in the public schools. Students could be identified by the student information forms (Appendix A). It turned out that eight of the students were in the data collected in the public schools. I now had pre/post data on some of the students who applied and were not accepted. The value of this kind of data had not been foreseen. Yet, it was critical to my findings.

Selecting Students for Interviews

A total of 22 students were interviewed. In the pilot study I had originally interviewed 7 students. An additional 15 students were randomly selected from the list of 90 students willing to be interviewed after the students were sorted into groups based on ethnicity and gender.

Interviews were conducted with a total of 6 white females, 5 white males, 4 African American females, 2 African American males, 3 Hispanic females, 1 Hispanic male, and 1 Asian American male. The number of students chosen in each category reflected the ethnic and gender makeup of the SSEP participants. All the interviews were conducted before mailing out the surveys to the remaining SSEP students.

Response Rate to Surveys

Surveys were mailed to all 135 SSEP students who were not interviewed regardless of whether or not I had been able to make phone contact. Thirty of the surveys were returned due to improper addresses. Either these 30 students had recently moved and left no forwarding address, or the student had moved over 6 months ago and the mail forwarding time was over. I received 38 completed surveys after making many phone calls asking students to please
complete and return the surveys. Including the 22 surveys from the students who were interviewed I now had a total of 60 surveys completed by SSEP students. This was 31% of the 157 who attended the SSEP.

After waiting about 6 weeks I decided to do a second mailing to the SSEP students I had not heard from (Appendix B). This time another 8 surveys were returned due to improper addresses. Why they had not been returned the first time is still a mystery. After several weeks an additional 22 surveys were returned. Again I spent a fair amount of time calling students for whom I had phone numbers asking them to please send back the surveys. Now I had a total of 82 surveys completed and returned, which is 52% of the students who attended the SSEP. In addition, 37 surveys were returned because they could not be delivered, while another 38 students never returned the surveys. One cannot conclude that the 38 students chose not to participate. It is possible that they never received the surveys.

Fifty-two percent is a good response rate for a survey. Out of the 82 students who had returned the completed surveys I had contacted 74 by telephone; in contrast only 8 had returned the surveys with no telephone contact. Telephone contact seems to have a positive impact on survey response rates. See Figure 3.2 for the breakdown of the survey response rate by ethnicity.
An interesting observation is that in general the survey response rate was lower for males than females. This difference might be explained by the lower number of male students whom I was able to contact by telephone.

**Limitations of the Study**

A significant limitation is the small number of students chosen for case studies. Students interviewed may not represent the population of students who participated in the SSEP. To minimize this possibility students were selected randomly from the pool of students who were willing to be interviewed.

Another significant limitation of this study is that the data was collected completely by self disclosed information provided by participants. This
information is highly subjective and open to bias. As mentioned earlier, response bias can occur when respondents misunderstand or fail to give an honest opinion. To help avoid asking questions that students misunderstood the researcher conducted a pilot study. Additionally, when conducting interviews the researcher reminded students to tell the truth especially at times when the respondents were uncomfortable about not meeting an expected interest in science.

Another limitation is that the researcher might be biased. The researcher might have had a stake in finding favorable outcomes. To minimize this limitation the researcher had others familiar with this type of research read the interview transcripts in order to validate the interpretation of the findings.

A limitation of conducting longitudinal studies is collecting all the required data in the early stages of a project. Unfortunately, those who planned the SSEP did not anticipate the need for collecting pre survey data on all the students who applied but were not accepted. However, I was fortunate and located several students who applied but were not accepted who had filled out the pre surveys at school. I was able to use this baseline for comparison purposes.

Another limitation of long term studies is locating students years after they participated in a program. However, this study suggests that talking to students by telephone may have had a positive impact on survey response rates. Locating students through schools was not very successful. In general, schools are required to protect the rights of their students and therefore are very careful, as they should be, sharing information about their students. Furthermore, even when schools were willing to cooperate and tried to help locate students, they provided some inaccurate information.
CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

Data Analysis

In order to investigate the impact, if any, of SSEP on students' science attitude and interest in scientific careers, a repeated measurement technique was used. Pre and post surveys for SSEP students were matched in the database. We found that 79 out of the 82 SSEP students who participated in this study had both pre and post survey data in the database. Only these 79 matched SSEP students' surveys were used for the following analysis. To determine if any change occurred over time in students' science attitude and interest in science careers, the null hypothesis was tested, at an alpha level of .05: mean in 1992-94 = mean in 1996-97. $H_0: \mu_{pre} = \mu_{post}$.

For comparison purposes over 500 non-SSEP students, who were in grades 7 through 12, from Holyoke and Chicopee public schools were also tested pre and post. At the junior high school level the non-SSEP students were all from heterogeneous classrooms, and at the high school level students were enrolled in standard level courses.

Quantitative Results

Comparison of SSEP and Non-SSEP Students

SSEP students were compared to peers who were in the same grades as SSEP students. For example, in 1992-1994 (pre) SSEP students were in grades 7 and 8, while in 1996-1997 (post) they were in grades 9, 10, 11 or 12. Therefore, non-SSEP students' surveys from grades 7 and 8 were used for the
pre comparison, while grades 9 through 12 were used for the post comparison. It is important to note the non-SSEP students scores were not from the same students pre and post.

A one-tailed t-test was used for all comparisons of SSEP students to non-SSEP students because I had every reason to believe that the intervention had a positive impact on SSEP students. Any p value that is less than .05 is considered statistically significant.

A two sample, one-tailed t-test found that there was a statistically significant difference (p < .0001) between SSEP and non-SSEP students' science attitude mean scores in 1992-1994 (Table 4.1). SSEP students had a more positive science attitude than non-SSEP students in 1992-1994 (SSEP mean was .95, non-SSEP mean was .28). In addition, a two sample, one-tailed t-test found that there was a statistically significant difference (p < .0001) between SSEP and non-SSEP students' interest in science careers mean scores in 1992-1994 (Table 4.2). SSEP students were more interested in science careers than non-SSEP students (SSEP mean was 21.8, non-SSEP mean was 13.6). SSEP students had a more positive attitude towards science than non-SSEP students and they were also more interested in science careers than non-SSEP students. This is not surprising as the SSEP students volunteered to take part in the two week summer science camp. In general, it was more likely that students who liked science would apply to attend a science camp than students who did not like science.

The following information refers to all Tables in Chapter 4:

- An explanation of science attitude mean scores: Students' science attitude mean scores could range from -2 to +2. Any negative integer would indicate a negative science attitude, zero
would be neutral, and any positive integer would indicate that a student had a positive science attitude.

• **An explanation of interest in science careers mean scores:** Students' interest in science careers mean score could range from 0 to 32. A mean score of zero means that a student is clearly not interested in a science career. Any score that ranges from 1 to 15 means that they are not interested in science careers. A score of 16 means that students are not sure or neutral about their interest in science careers. And lastly, a score above 16 indicates that students are interested in science careers. The higher the score above 16 the more they are interested in science careers.

Were these differences between students who attended camp and their peers still present in 1996-1997 (post)? A two sample, one-tailed t-test found that there was a statistically significant difference ($p < .0001$) between SSEP and non-SSEP students' science attitude mean scores in 1996-1997 (Table 4.3). SSEP students' science attitude started out higher than non-SSEP students and it remained higher over time. SSEP students' post mean score was .76, whereas, non-SSEP students' post mean score was -.06. In addition, a two sample, one-tailed t-test found that there was a statistically significant difference ($p < .0001$) between SSEP and non-SSEP students' interest in science careers mean scores (Table 4.4). SSEP students were more interested in science careers than their peers. SSEP students' post mean score was 16.7, whereas, non-SSEP students' post mean score was 10.2.

It is important to note that SSEP students' science attitude mean scores and interest in science careers mean scores were significantly higher than non-
SSEP students' science attitude and interest in science careers both pre and post. This limits the generalizability of the results to other groups, as the SSEP students started out different from other students in the cities selected.

**Non-SSEP Students Over Time**

This section is strictly about the effects of time on the average responses of different but comparable students. The purpose of this question was to determine whether any change over time observed with SSEP students was a change that occurred to all students in the schools that participated in this study. In order to calculate change over time in non-SSEP students all pre and post data collected from Holyoke and Chicopee were used. Pre included scores for students who were in grades seven and eight, whereas post included scores for students who were in grades nine through twelve. From Holyoke this included 237 pre and 261 post, and from Chicopee this included 681 pre and 329 post. According to the SSEP staff, the difference in numbers of students in the pre surveys is because the Chicopee school district was more willing than the Holyoke school district to cooperate administering the pre surveys.

**Science Attitude Survey:** An ANOVA was used to determine if there were any differences between 1) junior and high school students' attitudes towards science (mean scores), 2) junior high and high school students' attitudes towards science pre and post (mean scores), and 3) to determine if there was any interaction between pre/post and type of school.

The ANOVA showed that there was a statistically significant difference (p = .0002) between junior and senior high school students' attitude towards science mean scores (Table 4.5). There was a statistically significant difference (p = .0018) between students' science attitude pre and post mean scores.
among the different types of schools, and there was no interaction ($p = .3877$) between pre/post and school type.

Figure 4.1 shows that students in junior high (JH) had a slightly more positive science attitude than students in senior high (SH) in both 1992-1994 (JH .28, SH .13) and 1996-1997 (JH .17, SH -.06). In addition, there was a difference between junior high students' science attitude average scores from 1992-1994 to 1996-1997. Their science attitude decreased from .28 to .17. Also, there was a difference between senior high students' science attitude mean scores from 1992-1994 and 1996-1997 (it went from .17 to -.06). In general, students' science attitudes were more positive in 1992-1994 than they were in 1996-1997, and it appears that students in junior high had a more positive science attitude than students in high school in both 1992-1994 and 1996-1997. Overall it is important to note, that non-SSEP students had a very low science attitude both in 1992-1994 and in 1996-1997.

![Figure 4.1](image)

**Figure 4.1**
Non-SSEP students' science attitude mean scores
(Effect: school type split by 92-94/ 96-97)
Error Bars: ± 1 Standard Error(s)

JH = junior high school
SH = senior high school
Career Decision Making (CDM) Survey: An ANOVA was used to determine if there was any difference between 1) junior and high school students' interest in science careers (mean scores), 2) junior high and high school students' interest in science careers pre and post (mean scores), and 3) to determine if there was any interaction between school type and pre/post.

The ANOVA showed that there was no statistically significant difference (p = .4924) in students' interest in science careers mean scores between the different school types (Table 4.6). There was a statistically significant difference (p = .0005) between non-SSEP students' science attitude pre and post mean scores among the different school types. There was no interaction (p = .4894) between pre/post and school type.

Figure 4.2 shows that both junior and high school students were more interested in science careers in 1992-1994 than they were in 1996-1997.
Non-SSEP students’ mean score for interest in science careers ranged from 11.4 to 13.6, which indicates that students were not interested in science careers both in 1992-1994 and in 1996-1997. Overall, the two survey instruments together found that non-SSEP students from Holyoke and Chicopee had a very low science attitude and were not interested in science careers, and that their average science attitude and interest in science careers decreased slightly from 1992-1994 to 1996-1997.

We must keep this information in mind as we begin to look at whether or not SSEP students changed their science attitude and interest in science careers over time. If there is a small decrease in SSEP students’ attitude towards science and interest in science careers, which is similar to the change observed for non-SSEP students, it could be attributable to the schools students attended.
SSEP Students Over Time

Science Attitude Survey: To find out if there were any differences in SSEP students' attitude towards science over time a two-tailed, t-test was used. A two-tailed t-test was used whenever I made comparisons of SSEP students over time because I didn't know what the effect of time would be on students' attitudes towards science.

A two-tailed, paired t-test showed that there was no statistically significant difference ($p = .0820$) in SSEP students' science attitude mean scores between 1992-1994 and 1996-1997 (Table 4.7). SSEP students' science attitude remained high in comparison to non-SSEP students (in 1992-1994 it was .95, and in 1996-1997 it was .77). Even though there was no statistically significant change in students' attitude over time, one can see from Figure 4.3 that there was a downward trend which is similar to the decrease observed with a comparable group of non-SSEP students over time.

![Figure 4.3](image.png)

SSEP students' science attitude mean scores
Error Bars: ± 1 Standard Error(s)
CDM survey: A two-tailed, paired t-test showed that there was a statistically significant difference ($p = .0253$) in SSEP students' interest in science careers mean scores between 1992-1994 and 1996-1997 (Table 4.8). Figure 4.4 shows that SSEP students were slightly less interested in science careers in 1996-1997 than they were in 1992-1994 (pre mean score was 22, post mean score was 19.3).

![Figure 4.4](image)

**Figure 4.4**
SSEP students' interest in science careers mean scores
Error Bars: ± 1 Standard Error(s)

This decrease is similar to what was observed with non-SSEP students. In general, it seems that both SSEP and non-SSEP students lost some interest in science careers as they went from junior high to senior high school. However, it is important to note that SSEP students' were interested in science careers both pre and post, unlike non-SSEP students who were not interested in science careers both in 1992-1994 and in 1996-1997.

Overall, there was a downward trend in SSEP students' attitude towards science and a small decrease in SSEP students' interest in science careers.
Comparison of SSEP Students and Students Who Applied To the Program But Were Not Accepted

Science Attitude Survey: SSEP students' attitude towards science mean score was compared to students' who applied to the program but were not accepted science attitude mean score. Thirty-five students who applied to the program who were not selected to go to camp were contacted and completed the surveys. Because SSEP students were randomly selected from the applicants to participate in the program, it is safe to assume that students who applied but were not accepted had a high interest in science comparable to the SSEP students. Furthermore, it turned out that I had pre data on eight students out of the thirty-five students. The science attitude mean score of these eight students, in 1992-1994, was 1.38, which was above SSEP students' pre mean score of .95. This data suggest that the students who applied but were not accepted had an attitude towards science that was slightly above the attitude of students who were selected to participate in the program. This finding supports the assumption that the students who applied but were not accepted were comparable to SSEP students.

How did these two groups of students compare in their science attitude and interest in science careers over time? A one-tailed, two sample t-test found that there was a statistically significant difference (p = .0220) in students' post science attitude scores between those who attended camp and those who had applied but were not accepted (Table 4.9). Figure 4.5 shows that students who applied but did not attend camp had a greater decrease in their post science attitude mean scores than students who attended camp.
CDM Survey: Similarly, a one-tailed, two sample t-test found that there was a statistically significant difference ($p < .0001$) in students' post interest in science careers between students who attended camp and students who applied but were not accepted (Table 4.10). Figure 4.6 shows that students who applied but were not accepted showed a greater decrease in their interest in science careers over time.
Overall, these results clearly indicate that the camp experience had a positive long term impact on students' science attitude and interest in science careers. The students who attended camp maintained both a higher attitude towards science and a higher interest in science careers in comparison to students who applied but were not accepted.

The Effect of Variables

In this section I looked at the effect that variables had on students' attitude towards science and interest in science careers. We considered the effect of the following variables: gender, ethnicity, city students lived in, the grade SSEP students were in at the time they attended camp, the year SSEP students attended camp, and whether or not SSEP students were interviewed.
Gender

An ANOVA was used to determine if there was any difference between 1) male and female non-SSEP students' attitude towards science (mean scores), 2) male and female students' attitude towards science pre and post (mean scores), and 3) to see if there was any interaction between gender and pre/post. A separate ANOVA was used to determine if there were any differences between 1) non-SSEP female and male students' interest in science careers (mean scores), 2) students' interest in science careers pre and post (mean scores), and 3) to see if there was any interaction between gender and pre/post.

Non-SSEP Students. Science Attitude Survey: The ANOVA showed that there were no statistically significant differences (p = .0733) between female and male students' science attitude mean scores (Table 4.11). There was a statistically significant difference ( p < .0001) between female and male students' attitude towards science pre and post mean scores, and there was no interaction (p = .3837) between gender and pre/post.

Figure 4.7 shows that females' science attitude mean scores went from .25 to -.14 and males' science attitude mean scores went from .30 to .01. Both females' and males' science attitude decreased from 1992-1994 to 1996-1997. It is interesting to note that females' science attitude mean scores decreased slightly more than males'.
CDM Survey: The ANOVA showed that there were no significant differences ($p = 0.6005$) between female and male non-SSEP students' interest in scientific careers mean scores (Table 4.12). There was a statistically significant difference ($p = 0.0002$) between female and male students' interest in science careers pre and post mean scores, and there was no interaction ($p = 0.2182$) between gender and pre/post.

Figure 4.8 shows that both females' and males' interest in science careers mean scores decreased from 1992-1994 to 1996-1997. Again, it is interesting to note that females' interest in science careers decreased slightly more than males' interest over time. Females pre mean score was 14.2 and their post mean score was 11.2. Males pre mean score was 13.2 and their post mean score was 11.6. Based on these scores, the data suggest that both female and male non-SSEP students were not interested in science careers both in 1992-1994 and 1996-1997.
Figure 4.8  
Non-SSEP students' interest in science careers  
mean scores  
(year split by gender)  
Error Bars: ± 1 Standard Error(s)

**SSEP Students.** Science Attitude Survey: The ANOVA showed that there were no statistically significant differences (p = .7728) between female and male SSEP students' science attitude mean scores (Table 4.13). There was no statistically significant difference (p = .0836) between female and male students' attitude towards science pre and post mean scores, and there was no interaction (p = .6207) between gender and pre/post.

Both females' and males' science attitude mean scores did not change significantly over time; they remained high in comparison to non-SSEP students' scores. Females science attitude pre was .96 and post was .74, males science attitude pre was .94 and post was .83.

What one observes from Figure 4.9, even though there were no statistically significant differences, is that there was a noticeable downward trend for both females and males. Again, it is interesting to note that the downward trend was greater for females. One could interpret this to mean that females who start off with a high interest in science at the junior high school
level, lose more interest in science than a similar group of males as they go through high school. It is important to note that while SSEP females showed a downward trend in their interest in science as they went from junior high school to high school they were still more interested in science than non-SSEP students of either gender.

![Figure 4.9](image)

**Figure 4.9**
SSEP students' science attitude mean scores (pre/post split by gender)
Error Bars: ± 1 Standard Error(s)

CDM Survey: The ANOVA showed that there was no statistically significant difference \((p = .7731)\) between females' and males' interest in science careers mean scores (Table 4.14). There was a statistically significant difference \((p = .0269)\) between female and male students' interest in science pre and post mean scores, and there was no interaction \((p = .1427)\) between gender and pre/post.

One can see from Figure 4.10, that females' interest in science careers showed a greater downward trend than males' interest in science careers.
Females' pre mean score was 22.2 and their post mean score was 18.5, males' pre mean score was 21.0 and their post mean score was 20.6.

These are interesting findings, as many national reports have documented that women are underrepresented in science careers. It appears that female SSEP students showed a downward trend in science attitude and interest in science careers as they went from junior high to senior high school. In contrast, male SSEP students' science attitude and interest in science careers showed less of a downward trend than females'.

**Ethnicity**

An ANOVA was used to determine if there were any differences between 1) students' attitude towards science (mean scores) among the different ethnicities, 2) students' attitude towards science pre and post (mean scores) among the different ethnicities, and 3) to see if there was any interaction
between ethnicity and pre/post. A separate ANOVA was used to determine if there were any differences between 1) students' interest in science careers (mean scores) among the different ethnicities, 2) students' interest in science careers pre and post (mean scores), and 3) to see if there was any interaction between ethnicity and gender.

**Non-SSEP Students.** Science Attitude Survey: The ANOVA showed that there were no statistically significant differences ($p = .1612$) in non-SSEP students' science attitude mean scores among different ethnicities (Table 4.15). The difference between students' attitude towards science pre and post mean scores among different ethnicities could not be calculated due to the absence of data on Native American students' post mean scores, and there was no interaction ($p = .2238$) between ethnicity and pre/post.

CDM Survey: The ANOVA showed that there were no statistically significant differences ($p = .1046$) in non-SSEP students' interest in scientific careers mean scores among the different ethnicities (Table 4.16). The difference between students' attitude towards science pre and post mean scores among different ethnicities could not be calculated due to the absence on Native American students' post mean scores, and there was no interaction ($p = .7469$) between ethnicity and pre/post.

**SSEP Students.** Science Attitude Survey: The ANOVA showed that there were statistically significant differences ($p = .0229$) in SSEP students' science attitude mean scores among the different ethnicities (Table 4.17). There were no statistically significant differences ($p = .0857$) between students' attitude towards science pre and post mean scores among different ethnicities, and there was no interaction ($p = .6733$) between ethnicity and pre/post.
One difference in SSEP students' science attitude mean scores was between white and African American students. There was also a difference between Asian Americans and African Americans students' science attitude means scores. However this difference may be affected by the size of the Asian Group. Only four Asian American students participated in this follow-up. This is too small a number of students to base importance upon any difference discovered.

Figure 4.11 shows white SSEP students had a more positive science attitude than African American SSEP students both pre and post. White students' science attitude mean score was 1.2 pre and .89 post, whereas African American students' average score was .59 pre and .52 post.

These findings are not surprising, as it turns out that about 50% of the students who went to camp in 1992 were African American students from Springfield. (Ethnicity records were not kept in 1992. The estimate of 50% was obtained through conversations with SSEP staff.) Students were not randomly selected to attend camp during the first year. In 1992, the SSEP staff could only take about 25 students from Springfield. Going through a large school system like the Springfield public schools to locate a small number of students seemed inappropriate, so the SSEP staff turned to community groups for help. The project staff asked the community groups to help them recruit students. It turned out that some of the students who went to camp during the first year didn't even know they were going to a science camp. Many of these students were not very happy about the situation and actually disliked both science and the whole camp experience.
What this means is that the finding of difference between the white and African American students is meaningless. The two groups of students were not comparable. The African American students who went to camp in 1992 did not have a high interest in science like the rest of the students who went to camp.

**CDM Survey:** The ANOVA showed that there were no statistically significant differences ($p = .1345$) in SSEP students' interest in science careers among different ethnicities (Table 4.18). There was a statistically significant difference ($p = .0239$) between different students' interest in science careers pre and post mean scores among different ethnicities, and there was no interaction ($p = .2401$) between ethnicity and pre/post.

It is interesting to note that this instrument did not detect the above perceived differences in SSEP students' attitude towards science among different ethnicities. However, in general, the findings from the two survey instruments tend to support one another.
City

An ANOVA was used to determine if there were any differences between 1) students' attitude towards science (mean scores) among the different cities, 2) students' attitude towards science pre and post (mean scores) among the different cities, and 3) to see if there was any interaction between cities and pre/post. A separate ANOVA was used to determine if there were any differences between 1) students' interest in science careers (mean scores) among the different cities, 2) students' interests in science careers pre and post (mean scores) among the different cities, and 3) to see if there was any interaction between cities and pre/post.

Non-SSEP Students. Science Attitude Survey: The ANOVA showed that there was no statistically significant difference (p = .1951) in students' attitude towards science mean scores among the different cities (Table 4.19). There was a statistically significant difference (p < .0001) between students' attitude towards science pre and post mean scores among the different cities, and there was an interaction (p = .0002) between city and pre/post.

Figure 4.12 shows that students from Chicopee showed a decrease in science attitude from 1992-1994 to 1996-1997 (pre .30, post -.21). In contrast, Holyoke students' science attitude average scores remained pretty much the same over time (pre .15, post .11). The overall difference that was observed in pre/post for non-SSEP students is due in large part to the decrease in science attitude of Chicopee students.
However, it turns out the Chicopee school district cooperated more with Hampshire College while they were conducting the pre surveys. They were able to get 487 seventh and eighth grade students from Chicopee to participate in the pre surveys while only 112 seventh and eighth grade students from Holyoke participated in the pre surveys. One possibility is that the difference in sample size is responsible for the observed difference in Chicopee students' attitude towards science. If more students from Chicopee had participated in the post surveys the observed difference between pre and post may have diminished due to regression towards the mean.

**CDM Survey:** The ANOVA showed that there was a statistically significant difference ($p = .0107$) in non-SSEP students' interest in scientific careers mean scores among different cities (Table 4.20). There was a
statistically significant difference (p = .0002) between students' interest in science careers pre and post mean scores among the different cities, and there was no interaction (p = .4005) between cities and pre/post.

Figure 4.13 shows that students' pre mean scores were higher than their post mean scores for both Holyoke and Chicopee. Holyoke students' pre mean score was 14.5 and their post mean score was 12.6. Chicopee students' pre mean score was 13.4 and their post mean score was 10.4. One could interpret this to mean that non-SSEP students were slightly less interested in science careers in 1996-1997 than when they were in 1992-1994. Overall, because the means for both pre and post interest in science careers were below 16 I interpreted this to mean that both Chicopee and Holyoke students were not interested in science careers both in 1992-1994 and 1996-1997.

Figure 4.13
Non-SSEP students' interest in science careers mean scores
(Effect: city split by pre/post)
Error Bars: ± 1 Standard Error(s)
**SSEP Students.** As stated earlier, students from Springfield were not randomly selected to participate in camp during the first year. Therefore, any analysis of cities that included students who came to camp in 1992 would be inappropriate because of the difference in the types of students during that year. For this reason, I chose to look at the effect of cities using data from 1993 & 1994 only.

**Science Attitude Survey:** The ANOVA showed that there were no statistically significant differences (p = .2019) in SSEP students' science attitude mean scores among the different cities in 1993 and 1994 (Table 4.21). There was a statistically significant difference (p = .0145) between students' attitude towards science pre and post mean scores among the different cities, and there was no interaction (p = .4640) between city and pre/post.

Figure 4.14 shows that SSEP students from both Springfield and Chicopee had a decrease in their science attitude mean scores from 1992-1994 to 1996-1997. Springfield students' pre mean score was .966, whereas their post mean score was .57. Chicopee students' pre mean score was 1.1, whereas their post score was .72. This difference between Chicopee students' science attitude mean scores was also observed with non-SSEP students. Unfortunately, no non-SSEP students from Springfield participated in the school based surveys, so there is no way to compare these two groups.
CDM Survey: The ANOVA showed that there were no statistically significant differences (\( p = .1670 \)) between students' interest in science careers mean scores among the different cities (Table 4.22). There were statistically significant differences (\( p = .0126 \)) between SSEP students' interest in science careers pre and post mean scores for students who went to camp in 1993 and 1994. There was no interaction (\( p = .1333 \)) between city and pre/post.

Figure 4.15 shows that SSEP students, from Chicopee, who went to camp in 1993 & 1994, decreased their interest in science careers from 1992-1994 to 1996-1997. Chicopee students' pre mean score was 25.6, and their post mean score was 18.0. This finding supports the above observed difference in both SSEP and non-SSEP Chicopee students' science attitude mean scores. It appears that something caused a decrease in both SSEP and non-SSEP Chicopee students' attitude towards science and interest in science careers.
while for Holyoke and Springfield students the changes in attitudes towards science were not statistically significant.

Figure 4.15
1993 & 1994 SSEP students' interest in science careers mean scores
(Effect: pre/post split by city)
Error Bars: ± 1 Standard Error(s)

Grades SSEP Students Were In

An ANOVA was used to determine if there were any differences between 1) students' attitude towards science (mean scores) among the different grades students were in when they attended camp, 2) students' attitude towards science pre and post (mean scores) among the different grades students were in when they attended camp, and 3) to determine if there was any interaction between pre/post and grades students were in at the time they attended camp. A separate ANOVA was used to determine if there were any differences between 1) students' interest in science careers (mean scores) among the grades, 2) students' interest in science careers pre and post (mean scores), and 3) to determine if there was any interaction between pre/post and grades.
Science Attitude Survey: The ANOVA showed that there were no statistically significant differences ($p = .7834$) in SSEP students' science attitude mean scores among the different grades (6, 7, & 8) who attended summer camp (Table 4.23). There were no statistically significant differences ($p = .0822$) between students' attitude towards science pre and post mean scores among the grades, and there was no interaction ($p = .3822$) between pre/post and grades.

CDM Survey: The ANOVA showed that there were no statistically significant differences ($p = .7931$) between students' interest in science careers mean scores among the different grades that students attended camp (Table 4.24). There was a statistically significant difference ($p = .0264$) between students' interest in science careers pre and post mean scores among the grades, and there was no interaction ($p = .6169$) between grades and pre/post mean scores.

Figure 4.16 shows that eighth grade students' pre mean score was higher than their post mean score by a small amount, pre score was 22.6, and post score was 18.6. However, because both pre and post mean scores were above 16 it means that these students were interested in science careers both in 1992-1994 and 1996-1997. The overall difference observed with eighth grade students seems pretty comparable to the downward trend observed with the 6th and 7th grade students.
Unlike non-SSEP students, the SSEP students were all still interested in science careers. Overall, a more important finding about the impact of the camp experience is that there were no significant differences between 6th, 7th, and 8th grade students' interest in science careers that attended camp. They all had the same high level of interest in science careers before camp and over time, while there was a downward trend, they all had about the same level of interest in science careers. The downward trend in SSEP students' interest in science careers over time was similar to the decrease observed with the non-SSEP students.

**Year SSEP Students Attended Camp**

An ANOVA was used to determine if there were any differences between 1) SSEP students' attitude towards science (mean scores) among the different years that students attended camp, 2) SSEP students' attitude towards science
pre and post (mean scores) among the different years that students attended camp, and 3) to determine if there was any interaction between pre/post and the year students went to camp. A separate ANOVA was used to determine if there were any differences between 1) students' interest in science careers (mean scores) among the different years students attended camp, 2) students' interest in science careers pre and post (mean scores), and 3) to determine if there was any interaction between pre/post and the year that students attended camp.

Science Attitude Survey: The ANOVA showed that there were no statistically significant differences ($p = .1104$) between SSEP students' science attitude mean scores and the different years that students attended camp (Table 4.25). There were no statistically significant differences ($p = .0708$) between students' science attitude pre and post mean scores among the different years that students attended camp. However, there was an interaction ($p = .0232$) between students' science attitude mean scores and the year that students attended camp.

Figure 4.17 shows that students who attended camp in 1993 showed a large decrease in science attitude between 1993 and 1997. The science attitude mean scores of students who went to SSEP in 1993 decreased from 1.128 to .615. It is important to note that this is still a more positive science attitude than non-SSEP students had.
What might explain this difference? Was there anything unusual about the summer camp or the group of students during 1993? Females and males had separate summer camps during the first year (1992) only. In the two following years (1993 and 1994) the females and males attended camp together. In addition, another variable introduced was that during the first year SSEP was a residential camp while in the following years SSEP was a day camp. This change was made due to many difficulties encountered by the staff during the first year, as well as the high cost of running on overnight camp.

One possible explanation for the observed decrease in science interest of the 1993 SSEP group may be related to the change from a single gender to a co-ed summer camp. Or perhaps, it may be related to the change from a residential to a day camp. This seems like one possible explanation, as I discovered from the SSEP staff that in 1993 students resented the fact that the camp was not residential. Many of the SSEP students who went to camp in
1993, had talked to their friends who had gone the year before and were looking forward to it being a residential camp.

However, a more likely explanation for the observed decrease in students' attitude towards science in 1993 is related to the design of that year's program. At that time Hampshire College had been running for several years a summer workshop for the Coalition of Essential Schools. This summer workshop was designed to train teachers in how to use an inquiry-based approach to learning in science classrooms. In 1993, as part of their summer workshop, the Coalition of Essential Schools teachers ran part of the SSEP camp program. This did not turn out well for several reasons. First, the teachers were not experienced working with junior high students. Secondly, the teachers were not experienced using an inquiry-based approach. And lastly, there were problems integrating the teaching staff and the counselors.

Another interesting finding that I uncovered from the SSEP staff was that the females appeared to enjoy the science camp more when it was females only. In contrast, the staff found that the males were very difficult to manage when the camp was males only. In the two years that the camp was co-ed the males settled down, whereas, in the staff's opinion, the females didn't pay as much attention. Perhaps females' attitude towards science improved when they were in a female only science camp, while males' attitude towards science improved while they were in co-ed science camp.

To consider this possibility, I went back to the data and looked to see if there were any differences between females' and males' science attitude pre and post mean scores over the three years. We found that both females' and males' science attitude showed a downward trend by approximately the same amount in 1993. Females' science attitude went from 1.17 to .63, while males'
science attitude went from 1.05 to .58 (see Figures 4.18 and 4.19). The things that went wrong at camp during 1993 affected both males' and females' science attitudes in the same way. Additionally, there were no observed differences in females students' science attitude over time for those who went to camp when it was females only (1992) and when it was co-ed (1994). Thus, the females only residential camp in 1992 did not appear to affect their science attitude any differently than the co-ed camp in 1994. In contrast, there was an upward trend in males' science attitude over time for those who went to camp in 1992, when it was a single gender camp. Even though the staff said the males were difficult to deal with during 1992, it appears that their science attitude showed an upward trend over time. This was an unexpected finding.
Figure 4.18
Female SSEP students' science attitude mean scores
(Effect: pre/post split by year)
Error Bars: ± 1 Standard Error(s)

Figure 4.19
Male SSEP students' science attitude mean scores
(Effect: pre/post split by year)
Error Bars: ± 1 Standard Error(s)
CDM Survey: The ANOVA showed that there were no statistically significant differences ($p = .5468$) between students' interest in science careers mean scores among the different years students attended camp (Table 4.26). There was a statistically significant difference ($p = .0234$) in SSEP students' interest in science careers pre and post mean scores among the different years students attended camp, and there was no interaction ($p = .1359$) between pre/post and the year students attended camp.

Figure 4.20 shows that a decrease in students' interest in science careers mean scores occurred with the students who attended camp in 1993. Their interest in science careers average score was 22.7 pre, whereas their post score was 17.7. Students who attended camp in 1993 showed a decrease in interest in science careers from 1992-1994 to 1996-1997. Overall, students who attended camp in 1993, showed a decrease in both their interest in science careers and their attitude toward science.

![Figure 4.20](image)

*SSEP students' interest in science careers mean scores (Effect: pre/post split by year)

Error Bars: ± 1 Standard Error(s)
**SSEP Students Interviewed vs Not Interviewed**

An ANOVA was used to determine if there was any difference between 1) students' attitude towards science (mean scores) among those interviewed and those not interviewed, 2) students' attitude towards science pre and post (mean scores) among those interviewed and those not interviewed, and 3) to determine if there was any interaction between pre/post and whether or not students were interviewed. A separate ANOVA was used to determine if there was any difference between 1) students' interest in science careers (mean scores) among those interviewed and those not interviewed, 2) students' interest in science careers pre and post (mean scores) among those interviewed and those not interviewed, and 3) to determine if there was any interaction between pre/post and whether or not students were interviewed.

**Science Attitude Survey:** The ANOVA showed that there was no statistically significant difference ($p = .5127$) between SSEP students' science attitude mean scores among those who were interviewed and those who were not interviewed (Table 4.27). There was no statistically significant difference ($p = .0802$) between students' science attitude pre and post mean scores among those interviewed and those not interviewed, and there was no interaction ($p = .1756$) between pre/post and whether or not students were interviewed.

**CDM Survey:** The ANOVA showed that there was no statistically significant difference ($p = .3364$) between students' interest in science careers mean scores among those interviewed and those not interviewed (Table 4.28). There was a statistically significant difference ($p = .0251$) in students' interest in science careers pre and post mean scores among those interviewed and those not interviewed, and there was no interaction ($p = .2717$) between pre/post and whether or not students were interviewed.
Figure 4.21 shows that students who were not interviewed showed a small decrease in interest in science careers between 1992-1994 and 1996-1997, whereas for students who were interviewed interest in science careers stayed the same. Students' who were not interviewed pre mean score was 21.9 while their post score was 18.5. It is important to note that all of the SSEP students still had an interest in science careers, unlike non-SSEP students, because their mean scores were above 16.

It is important to the validity of the data collected that the students who were interviewed were not influenced by the interview process. Because there were no observed differences between SSEP students' science attitude mean scores among students interviewed and those not interviewed, it is unlikely that there was any impact of the interviews on students' responses to the surveys.
Summary of Quantitative Results

Statistical analysis of the results obtained from the two survey instruments revealed the following:

• SSEP students had a more positive attitude towards science and interest in science careers than non-SSEP students.

• SSEP students’ attitude towards science and interest in science careers remained higher than non-SSEP students over the time period studied.

• Both SSEP and non-SSEP students attitude towards science and interest in science careers decreased by a small amount as they went from junior high to high school.

• Students who applied but were not accepted to SSEP started off with a high interest in science, like SSEP students, however their interest in science decreased much more than SSEP students interest in science over the time period studied.

• The effect of gender on students’ attitude towards science and interest in science careers revealed that both SSEP and non-SSEP females interest in science decreased more than males over time.

• The effect of ethnicity on students’ attitude towards science and interest in science careers revealed no differences among the different ethnicities for non-SSEP students. The difference between African-American and white SSEP students’ attitude towards science and interest in science careers can be attributed to the method of recruited of African-American students.

• The effect of cities on students’ attitude towards science and interest in science careers revealed that students from Chicopee had a greater decrease in interest in science than students from Holyoke.
• The effect of grades students were in when they attended camp on their attitude towards science and interest in science careers revealed no differences.

• The effect of the year students attended camp on their attitude towards science and interest in science careers revealed that students who attended camp in 1993 decreased their interest in science. This was attributed to the way camp was run that year.

• The effect of interviews on students’ attitude towards science and interest in science careers revealed no important differences.

Qualitative Results

I interviewed a total of 22 students who attended SSEP during the years 1992-1994. I was able to get a representative sample that reflected the ethnicity and gender of the population that attended SSEP. Following is the breakdown of the gender and ethnicity of the group of students interviewed: 6 white females, 5 white males, 4 African American females, 2 African American males, 3 Hispanic females, 2 Hispanic males and 1 Asian American male.

I interviewed a mixture of students who attended camp over the different years. Of the 22 students interviewed six students went to camp in 1992, seven students went to camp in 1993, and nine students went to camp in 1994. In addition, I interviewed a variety of students from the three Western Massachusetts cities that attended camp. Of the 22 students interviewed, eight were from Springfield, ten were from Holyoke, and the other four were from Chicopee.

The interviews were coded using HyperRESEARCH from ResearchWare. It was not surprising to learn that for 10 students, out of the 22 interviewed, the favorite school subject was science. That’s 45% of the interviewed students.
Most of the SSEP students had volunteered to participate in a two week summer science camp. They liked science when they went to camp, and years later 45% of the students who were interviewed said that their favorite subject was science.

**Nature and Extent of Impact**

Over seventy-five percent of the interviewed students spoke about how SSEP increased their interest in science. It is my assumption that students' interest in science correlates with students' science attitude. To put in another way, if students are interested in science then I believe that they have a positive attitude towards science. Following are a few excerpts from the interviews that demonstrate this point. (To protect students' confidentially each student was assigned a case number. In addition, when I felt it would be useful to the reader, I included the questions asked during the interviews.)

**Case 03**, a white female sophomore from Holyoke, SSEP 1994

Science was just another subject in school. No big deal you just had to pass it. When I went to Hampshire College it was fun and it changed a lot of what I thought about science. I became more like passionate for it. I had more respect for nature and animals.

**Case 12**, a white female sophomore from Chicopee, SSEP 1994

*Did the summer camp affect your attitude towards science?*

Well, I already basically enjoyed science, I just enjoyed it more after Hampshire College. It made me more positive towards science. It just made me realize that I wanted to go into the science field. It made me positive that was something that I wanted to do.
Case 15, a white male junior from Chicopee, SSEP 1993

I think it helped me excel more in science. Something wasn’t happening in the work I was doing at school. It really brought my self-esteem up about the subject of science. So it really helped me out a lot.

I think it made me have a better outlook on science. It was really a fun subject. If you really took the time to learn it you could excel into it and get a career out of it, if you were serious about it. It was a lot of fun. It helped me get a better aspect of the subject.

Case 16, an African American female college freshman from Springfield, SSEP 1993

When you applied to this program how did you feel about science?

My teacher kind of convinced me to do it. I didn’t want to do it because I thought I wasn’t smart enough. I was going to be around kids that were so smart and knew a lot about science. She said just do it. And it’s true when I went to the program I didn’t find science as boring, it was something a little more interesting.

I think after SSEP I was kind of excited about science. I think I left there admiring it more, the environment of learning, thinking science was fun.

The above statements by students are testimony that students increased their interest in science due to their experience at summer science camp. We know that most students who attended the camp had a high interest in science to begin with. However, based on these findings I believe that the program may have further enhanced their science attitude. This may have led some students to consider majoring in science, while the impact may have been less on other
students. Perhaps because of the experience some students took more science courses in high school or perhaps students developed an appreciation for science that they didn’t have before going to camp. While the long term goal of the program may have been to try and get more students from under-represented groups into science careers, producing students who appreciate science was also a worthwhile goal, as we need citizens who understand the importance of science in today’s society. Furthermore, an appreciation for science may lead some students to choose science careers.

Aspects of SSEP that Increased Students’ Interest in Science

What aspects of the program increased students’ interest in science? The interview data suggest that it had to do with the fact that students really enjoyed the activities they did at camp. Students who attended SSEP had the opportunity to explore science in a fashion that helped them understand that science could be fun and interesting to do. Seventy percent of the students interviewed mentioned that they really enjoyed the experience. The following excerpts demonstrate what made science at camp enjoyable for students.

Case 02, an African American female junior from Springfield, 1992

Tell me about your experience at Hampshire College.

We did dissecting. We did tendons in chicken, a lambs eye, a cows heart, and a brain. At the farm, they had cut the side of a cow and they gave you a glove and you could reach into the cow’s stomach and feel all the stuff she’d eaten and you could feel the stomach contract. Cow’s alive and still eating too you know. The cow didn’t even know you’re inside its stomach. You stick your hand in real deep and you could pull out food if you wanted to.

We loved the labs. They had such great labs. They had everything we needed, just had know how to use
it and get it ready. We studied bacteria in our mouths. It was great. If schools had labs like at Hampshire College it would be science at Hampshire College at school. I liked Hampshire College labs.

Case 05, a white female sophomore from Holyoke, SSEP 1992

Tell me what you remember about the program.

I remember it was fun. I remember going to a pond once and we got tadpoles and bugs and all that. I liked doing that. The dissecting that was good. We dissected a sheep’s brain, a sheep’s eyeball, and a cow’s heart. At first I thought it would be disgusting but once you actually did it, it wasn’t that bad. The only thing that I didn’t like was the brain that was disgusting I didn’t like that one. It wasn’t as gross as I thought it would be you just do it and it’s like nothing.

Case 09, a Hispanic female freshman from Holyoke, SSEP 1994

Tell me what you remember about the program.

We had these classes. I don’t know what they were called but we did experiments, they were like orange [petri dishes]. We put it in like this refrigerator [incubator] or whatever it was. We got it out to see if it was contaminated. It was interesting. About the bones, different bones, the heart and eyes. We took apart bones, I think it was from (she couldn’t remember), what was it. It was fun.

Case 10, a white male freshman from Springfield, SSEP 1994

Tell me about your experience at Hampshire College.

We would like dissect frogs, we dissected a cow’s brain and the heart from a sheep. We would watch videos and about cave men and stuff like that. The teacher she was real nice. We watched a lot of videos. It was really fun. I really had fun with science. Teachers made it fun, so it made it
enjoyable to learn science. You learned science and it was fun.

Case 12, a white female sophomore from Chicopee, SSEP 1994

**How was your experience like or different than school science?**

It was different because I knew didn't have to like get a certain grade. It was more like learning but not feeling the pressure. It was fun. I learned a lot more than like I did in a year at school.

From these excerpts it is quite evident that students vividly remembered the dissections. However, it is clear that besides dissections, there were other aspects of the program that made it enjoyable for students, such as: 1) students enjoyed doing hands-on lab activities, 2) the content covered at camp was interesting to students, 3) the teachers created an enjoyable atmosphere, and 4) there was no pressure on students for grades. One of the things that clearly stands out about the camp was that a diverse population of students had the opportunity to do advanced level science. This may have enticed some of the students to consider taking higher level science classes at high school.

In general higher level science classes in high school are reserved for college bound students. Students with little interest in college end up getting less challenging science courses that may not include labs. Seventy-five percent of the SSEP students that I interviewed were enrolled in college track science courses. The few SSEP students who were not in college track science courses were enrolled in vocational high schools or they had opted for lower level science courses because of their present low interest in science. Overall, the interviews suggest that students' interest in science may have increased because they enjoyed learning science at camp.
SSEP Students Learned Ahead

An added benefit of attending SSEP was that the summer camp helped many diverse students with their future science classes at school. Seventy percent of the students interviewed said that they felt the camp experience had helped them in school. They felt better prepared.

Case 04, an African American female junior from Springfield, SSEP 1992

Now I’m not afraid of dissecting anymore. In biology I dissected an earthworm and a frog. In Anatomy and Physiology I dissected a rat, a pig, and a cat. The experience at Hampshire College helped me recognize parts of the body and the shape of it. I learned parts of the digestive system, bones and heart, the circulatory system at Hampshire College. I remember the heart real well. I see the drawing and it just hits me, the four chambers of the heart. It helped me learn. I’m lucky to not be afraid of dissecting.

Case 05, a white female sophomore from Holyoke, SSEP 1992

Last year in science we started the metric system. I already knew everything because I had learned the metric system at Hampshire College, so it made it a lot easier. It helped out a lot too because even in my science now what I learned at Hampshire College we’re going over now.

It made it easier at school. I understood it better because I already knew it, so it was kind of a review, so I did better.
Case 07, an African American female junior from Springfield, SSEP 1992

It prepared us more for high school and maybe even college, because we had lectures and stuff like that, and it wasn’t always book work in class, and that was good. It was like you had do your book work at home and if you had problems you’d come back and ask questions.

The science classes made me like science more than I did before. The bone study that helped me a lot because all three years of high school science covered something about the skeletal system. Learning about the microscopic life in the water that helped me a lot because we did a lot of that stuff last year. That got me prepared for it so that when I seen it in a book and I heard it, it wasn’t like the first time that I heard about it. It was the second time I’d seen or heard about it, that made it easier. The math classes that helped me out a lot in my freshman year of math. Because I knew more and it was easier to understand.

Case 14, a Hispanic female sophomore from Holyoke, SSEP 1994

At first, I didn’t like science, it was frustrating. It was like hard. I always got C’s in science but then I went to Hampshire College and that really helped me a lot. It like interested me in science. We actually got to do stuff. And this year I got an A. I use some of the stuff that I used at Hampshire College. I still have a lot of papers and I use those for my classes.

Case 18, a white male junior from Chicopee, SSEP 1993

Last year in microbiology, they started talking about some stuff that came back in my memory. In geometry we are seeing how high one object is from one point on the ground when you only have a certain distance using algebraic equations and I remember doing that at Hampshire College.
Case 19, an African American male sophomore from Springfield, SSEP 1994

We dissected a frog in 8th grade and I already knew what I was doing because we did that at Hampshire College. That made me feel good. I went around helping other people because I was already done.

You learn about things you’re going to learn next year in school. You are advanced already because they are showing you what’s at college instead of just middle school stuff. You are going to learn more than everybody else.

Learning science before they would normally at school made many of the students that attended camp feel good about science years later in their science classes. Science was easier for them because they had already learned the material.

Factors that Affect Students' Science Attitudes

Are students who feel good about science more likely to achieve in their science classes than students who dislike science? Several students interviewed mentioned that they felt that grades affected their attitude towards science.

Case 06, a white female junior from Holyoke, SSEP 1992

What made your biology class so interesting?

Well, the teacher would talk to us. We watched videos that were really interesting, that other teachers wouldn’t have used because they were so controversial, like evolution and AIDS. I think you have to talk about that in biology. He didn’t have to have like a videotape he could have just told us the
facts. It was really interesting. It was fun. It wasn’t stressful. I think a lot of kids are turned off by science because they feel they can’t do it.

Why do students feel that way?

Because science just has this image, it’s so negative almost because it seems like you just can’t do it. Because it’s harder, because in some classes you understand easier. I know for me that I try harder if I understand it, if I have a better time. If I get a bad grade on a test I know I have to work harder but I also think I have less chance of reaching that A or understanding all of it, or liking it.

Case 14, a Hispanic female sophomore from Holyoke, SSEP 1994

Tell me what is it about science that you like?

At first, I didn’t like it, it was frustrating. It was like hard. I always got C’s in that class but then I went to Hampshire College and that really helped me a lot. It like interested me in science. We actually got to do stuff. And this year I got an A.

Case 15, a white male junior from Chicopee, SSEP 1993

What makes you like a subject, the way it’s taught, the teacher, what’s the most important thing for you?

Probably because it’s easy. The subject is easy to understand, easy to learn. It’s not a hundred different things coming at you at one time. The teacher also affects how you do in the class, that’s how I feel. It’s mainly how easy it is for you to remember.

Thus, it appears that students like subjects that they get good grades in. This is not surprising. The challenge for today’s science educators is to provide
opportunities for underrepresented groups of students to achieve in their science classes. I believe that in order for students to achieve they need to be interested in the subject area.

Factors that Make Science Classes Interesting

What makes students interested in science? Most of the students I interviewed were able to verbalize what would make their science classes more interesting. In addition, several students spoke about how they were willing to put more effort into their science classes if they were more interested in the material being presented.

Case 02, an African American female from Springfield, SSEP 1992

I like science but I don’t like the structured science they give you at school. When I went to the program it was a lot more hands-on touchy freely. I guess in school they just don’t have that kind of time. There’s a limit.

What affects your attitude about a subject the most?

The way they teach it. If it’s like quiet I’m going to show you how to do it. You don’t want to learn it that way. You want to be able to try and test what the teacher says. Like why do you do that? Kind of a laid back class where there’s not too much of a tight grip, where you can’t stand the teacher. Something that makes you excited where you can talk about and discuss it. Where like she can put something on the board and say OK I can understand why that might not be right and you can talk to her and say something about it.

Case 03, a white female sophomore from Holyoke, SSEP 1992

I think science should be a lot of hands-on because I think you learn more when you are able to touch it
and be able to see for yourself. You might not be able to understand what they’re saying but if you have it in front of you, you’re looking at it, and you get to examine it yourself. I think it’s a lot easier. All hands-on I think is a lot easier than having to sit there and listen.

Case 14, a Hispanic female sophomore from Holyoke, SSEP 1994

It’s better like to do more projects, not like every time but if you have certain topics that you want to make the students really understand or they’re not going to be bored with it. They should like make it more interesting. Get at some stuff that’s related to that.

Case 15, a white male junior from Chicopee, SSEP 1993

I like science. It’s a pretty good subject but it all depends on how you learn it. If a teacher breaks it down for you, if they really go in-depth in the subject instead of like my teacher now who just gives the notes and expects you to learn everything. At my age, you stop and look and say “Am I ever going to use this in life?” and I think that’s a big problem because you gain a negative aspect of the subject. You say I’m never going to need to know about this muscle or that or how this functions. Basically that is how it is now. If they don’t take the time to go in-depth and really make you study it and help you excel in the subject than it’s not really that much fun. You gain a negative aspect and you just feel like dropping it.

Case 18, a white male junior from Chicopee, SSEP 1993

Why did you like science some years more than others?

The stuff we were learning. I paid more attention if it was interesting, I put more effort into it, the other stuff was like boring.
Case 21, a Hispanic male freshman from Springfield, SSEP 1994

I like it when the teachers tell us to do something and then we do it and discuss it to make sure we really understand it.

Many students interviewed were able to identify the methods that would help improve their interest in science classrooms. The interviews show that students were able to identify some of the key components needed to improve science teaching and learning. Students want less structured science classes with less time devoted to lectures and note taking. Instead, they want the opportunity to do hands-on science activities that are relevant to their lives, the chance to discuss issues, and the time to explore issues in-depth. These components are advocated for by today's educational experts. However, Nieto (1994) points out that students' perspectives are rarely heard. The point is that students' voices should be heard and taken seriously.

**SSEP Students Considering Science Careers**

Thirty percent of the students interviewed said that they were planning on pursuing science careers or science related careers. It is not surprising that some of the students who attended the camp are considering science careers. After all, some of the students interviewed had a high interest in science. What is more of a concern is why the majority of students were not considering a science career. What happened to the other students' interest in science careers? Students' interest in science may have been affected by many other external factors in their lives. In the next section, I will identify some of the factors that affected SSEP students' interest in science.
Other Factors that Impact Students' Interest in Science

According to the students interviewed the greatest influence on students' attitude and interest appears to be teachers. Over sixty percent of the students spoke about how teachers influenced their attitude. They felt that teachers had a great impact on their interest in a subject. Following are excerpts that demonstrate the impact teachers have on students' attitude.

The Influence of Teachers

Case 01, a white female junior from Holyoke, SSEP 1992

Have you had any good science classes over the years?

I enjoyed my freshman class. It was earth science. I think it was like geology and stuff like that. I liked the teacher. I liked what was going on. I wasn’t bored. It was really interesting to me.

What made this course good? Can you describe it a little more?

I liked the teacher. He was a nice guy. He would go over everything at least five times and you wouldn’t feel like you didn’t know what you were doing. He would explain it to you so that you could understand it.

What’s science like in high school?

Last year my science teacher wasn’t good. He just made us read and do questions. If it’s just that all the time then it’s not interesting. There’s not much you can do with that and the teacher wouldn’t give you a chance to talk. He would just make us do questions and read. That’s it.
Case 06, a white female junior from Holyoke, SSEP 1992

Tell me about your advanced chemistry class.

Some of the things in chemistry I have loved and picked up on right away and I have done well in it. Then there is other stuff that I'm like why is this important. We don't get to ask questions, she gives notes, you read the chapter, you do the vocab, test. My biology teacher last year loved biology, it was great. I had so many questions, it was so interesting. It was a hard class but I did OK.

Case 07, an African American female junior from Springfield, SSEP 1992

What do you think is the most important thing that affects your attitude towards a subject?

The teacher and what the subject is about. When a teacher spends some time with you learning. When they don't just tell you what it is and then just keep moving on without seeing if you understand it first, that affects your attitude towards the subject.

Case 15, a white male junior from Chicopee, SSEP 1993

What science course are you taking this year?

This year I am taking Biology II. It's about the human body, skeletal and different systems of the body and how they function.

How do you like the course?

It's pretty good. The teacher could be better. It's a pretty good class. We are going over what I learned
in seventh grade and I really excelled in that class. I had a better teacher then, he really explained things. This one, she tells us to read, she gives the notes, she goes a mile a minute. Also the book doesn’t make much sense, it is hard to understand. It’s an all right class but it could be better.

Tell me about the science class you took last year?

Biology. It was really fun. I had a great teacher. He was a real fun teacher. Class was really good and I did pretty good in that class last year.

Case 16, an African American female college freshman from Springfield, SSEP 1993

What do you think affects whether you like a subject?

I think it’s the teacher unless you have just have a love for the subject. Unless you just like that subject. Because a lot of times when the teacher makes it fun to learn then you are going to be interested in the subject, I think.

Tell me about your chemistry class.

It was really difficult because of the teacher. I did switch teachers and it did make a big difference. In my junior year you could tell my teacher was really smart and knowledgeable but he couldn’t teach. If you asked a question he would intimidate you like you don’t know this. He would just expect you to know it. He would talk to you like he was talking to a colleague, he would expect you to know what he was talking about. He didn’t explain things. His tests were crazy.
What was the teacher like in your senior year?

He made it interesting. He explained things and he would not go on until everybody understood. He was really concerned that everybody learn his subject. He wanted you to learn it.

Several other important external factors that influence students' science attitude and interest in science careers were uncovered during the interviews. These included the following: parents, the schools students attended, school officials, outreach programs, television, and science clubs. The above influences are listed in decreasing order of frequencies they were found in the interviews. Following are selected excerpts from the interviews about these external influences.

**The Influence of Parents**

Case 09, a Hispanic female freshman from Holyoke, SSEP 1994

Are you thinking about going to college?

Yeah. I don’t know what I’m going to do when I grow up. When my mom was young she graduated from school and everything and she wanted to keep going on and become like a nurse. But my grandma she got sick so my mom she had to go back to Puerto Rico and take care of her. So my mom couldn’t study, nobody to drive her. My mom tells me “study, study, I wanted to study but I couldn’t, I want you to study”.

137
The Influence of Schools Attended
Case 03, a white female junior from Holyoke, SSEP 1992

When was your first good experience in science?

In sixth grade at Magnet Middle school.

The Influence of School Administrators
Case 02, an African American female junior from Springfield, SSEP 1992

Are you thinking about going to college after high school?

In not thinking about it, it’s a must. My principal wants me to think about teaching and I mean I like it. I know I don’t want to do anything in medicine. Something that has to do with people and kids. Something like that.

The Influence of After-School Programs
Case 14, a Hispanic female sophomore from Holyoke, SSEP 1994

What are you thinking about doing after high school?

I am going to college to study occupational therapy.

How did you make that decision?

I am in the Outreach Program. It’s a program that deals with health careers. They take us on field trips.
Is this program at your school?

Yeah. What they do is like take us to colleges and give us information. They tell us like so we know more about careers. They give us jobs. They pay us but it is all volunteer work. I worked at the hospital because I was interested in occupational therapy but I wanted to get my hands on it. It is better like that because you really know if you want that or not.

The Influence of Television

Case 12, a white female sophomore from Chicopee, SSEP 1994

When did you start liking science?

When I was little I use to watch Mr. Wizard every morning.

The Influence of Science Clubs

Case 18, a white male junior from Chicopee, SSEP 1993

How long have you been in the science club?

Since my freshman year. Three years now. In my freshman year it wasn’t that active but then last year we got a new teacher. Last year we entered a contest at some place in Florida, we were supposed to go down there. We built a robot and we were supposed to compete against other schools in the United States but we couldn’t do that because we couldn’t raise enough money. But the money we raised last year is going for this year. This year we have a full sponsor. We raised $10,000, we had a candy sale. We are going up to New Hampshire in March to compete. We didn’t start building it yet. We have to wait till the competition starts in January and then we have six weeks to build it with our sponsor, a company in Wilbraham. They are engineers. If we do good (sic) in New Hampshire than we fly down to Florida and compete at the national level. That will be fun. I am looking forward to that.
Other Ways Students Benefited

In addition to increasing students' interest in science, the benefits of attending SSEP ranged from increasing students' interest in college to gaining social skills. Because SSEP was held at Hampshire College, students were able to get a sense of what college life might be like. It was the first time that some of the students had gone to a college campus.

It was interesting to learn that over seventy percent of the students interviewed mentioned that they made new friends. This is an important benefit of the program as interpersonal skills are necessary for participation in today's society. Students who attended SSEP had the opportunity to work with an ethnically diverse population of students. SSEP students had the chance to make friends with students who were ethnically different than themselves.

SSEP Increased Students' Interest in College

Case 04, an African American female junior from Springfield, SSEP 1992

It gave me a view of college life and how science departments work.

Case 06, a white female junior from Holyoke, SSEP 1992

The whole college experience at that age, to just get a feel for it, to know that it's worth working for.

The whole experience of it, going to class, it was really like going to college. Being on your own. I loved it. It was really the best time. You did work but you didn't even care, you loved it. We had free time, you could choose what to do with that.

I got a little more confident and more assured about my ability because I went off for two weeks without
my parents, alone, I felt fine. I had a chance to excel. I had fun. You really interacted with people. And that’s one of the things to this day that I’m not afraid to go to college because I managed to get along with all these different people and make friends. You learned to get along with people that you really didn’t like because you had to put up with them because they were there.

I made a lot of really good friends. Some of the people I’m not really friends with anymore because I just don’t see them. To me knowing that you don’t have to worry about college is great. I think you got a feel for what it’s like, just the fact that you can go off on your own, and learn, and like it, and enjoy yourself. That was probably the best part of it.

**SSEP Increased Students' Social Skills**

Case 02, an African American female junior from Springfield, SSEP 1992

It’s was good because you might not have the chance to work with a lot of different kids from a lot of different areas and that’s good.

Case 05, a white female sophomore from Holyoke, SSEP 1992

**Did you learn any other skills besides science at Hampshire College?**

I think meeting new people because before that I never really went places without my friends, like to go and meet new people. I remember before I went, and I knew I was accepted, I didn’t want to go because I didn’t know anyone who was going. So once I got there it was like you just meet all these new people. So I think I learned how to talk to people better and meet new people.
Case 09, a Hispanic female freshman from Holyoke, SSEP 1994

I think the program was pretty good, you got to know other people and other personalities. You had experiences together. You played together and you worked together in groups and shared different things.

Case 12, a white female sophomore from Chicopee, SSEP 1994

It was a good experience, to be with other people that enjoyed the same thing. You got to know a lot of other people from a lot of other places. It wasn’t just the same kids that you see at school every day, it was other kids, and you interacted with them.

Case 18, a white male junior from Chicopee, SSEP 1993

I remember the first two days we had socializing skills. They took what we wrote down and we had to pick up the main ideas and you had to go around asking. Do you do this for a hobby and is this your favorite color? I remember doing something like that.

I met new people and got to talk to them. I think that led me to go on to student council. I’m into that socializing, I’m not afraid to speak in front of people.

Do you think going to Hampshire College had anything to do with that?

Yeah, I think so. I remember I was kind of shy back then. That was my first real time like dealing with new people. It was like going to a whole new city.
Case 19, an African American male sophomore from Springfield, SSEP 1994

You learned how to get along with other people. They would have us get into different groups everyday, so you got to know everybody that was there, instead of learning just one group of people.

The above excerpts clearly demonstrate that students enjoyed meeting and working with a diverse population of students. They made friends quickly at camp. This is not surprising as the program was structured to help students form new relationships.

Aspects of the SSEP that Increased Students' Social Skills

Collaborative learning activities were used to get students to work with one another. The SSEP staff created an environment that fostered and nurtured students working with one another. This was apparent from the interviews as several students spoke about the positive atmosphere at camp.

Case 02, an African American female junior from Springfield, SSEP 1992

When I went there it wasn’t that stuff you get taught by a teacher like sit down and be quiet. You get to talk to people, discuss things, explain your ideas, you have an opinion, you speak about it, and you have freedom. Learning is fun if you’re in the right environment.
Case 04, an African American female from Springfield, SSEP 1992

I learned to open up more, to let others know what I think. I have always been afraid of participating because I was afraid of getting the wrong answer but I wasn’t afraid at Hampshire College. I didn’t have to be afraid.

Case 05, a white female sophomore from Holyoke, SSEP 1992

It was more like a whole group effort thing than just like listening to the teacher. Everyone could say what they were thinking.

How did that make you feel?

I thought it was better because sometimes people don’t feel comfortable like asking questions but there (at Hampshire College) it was different because everyone else was asking questions. So you felt more comfortable asking them. It was easier than listening to just what the teacher was saying and writing notes and all that. It’s easier if you can actually talk to the teacher and ask them stuff.

Case 10, a white male freshman from Springfield, SSEP 1993

It wasn’t like at school with kids laughing at you. We were all friends. The atmosphere at Hampshire College was fun.

I felt closer to the kids. You could get involved a lot easier and talk. The teachers got involved. You could make a comment and stuff and not worry about the kids laughing at your comments or saying whatever. You could open up and talk like it was like your family. They were all your friends. That’s what I enjoyed about it. Me, I never had that much fun in school because kids were always bothering me. No
one treated you different. Everyone treated you equal and that to me made a difference.

Traditional classrooms often stifle students. In many classrooms students are afraid to speak up for fear that they may have the wrong answer. In addition, some students are afraid of being criticized by their peers. In contrast, the SSEP staff were able to create an environment where students felt safe to voice their opinions and share information with one another. In addition, students at the summer science camp had the opportunity to discuss issues instead of just being lectured to as happens in many classrooms. Furthermore, it is clear that students enjoyed being actively engaged in science discussions.

**Summary of Qualitative Results**

The interviews revealed the following:

- Forty-five percent of the students interviewed favorite subject was science.
- Seventy-five percent of the students interviewed said that SSEP increased their interest in science.
- Seventy-percent of the students interviewed said they really enjoyed the summer science camp experience.
- Seventy percent of the students interviewed said that the summer science camp experience helped them do better in school.
- Students interviewed said they like subjects they do well in.
- Students said they would like more hands-on science that is relevant to their lives, the chance to discuss issues, and the time to explore issues in-depth.
- Only thirty percent of the students interviewed plan on pursuing science careers.
• Many factors besides SSEP affected students interest in science (teachers, parents, schools attended, school administrators, after-school programs, television, and science clubs).
• SSEP increased students' social skills.
Table 4.1
Two sample t-test
Comparison of SSEP and non-SSEP students' science attitude mean scores, 1992-1994

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Table 4.2
Two sample t-test
Comparison of SSEP and non-SSEP students' interest in science careers mean scores, 1992-1994

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Table 4.3
Two sample t-test
Comparison of SSEP and non-SSEP students' science attitude mean scores, 1996-1997

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Table 4.4
Two sample t-test
Comparison of SSEP and non-SSEP students' interest in science careers
mean scores, 1996-1997

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Table 4.5
ANOVA Table
Effect: school type * pre/post
Non-SSEP students' science attitude mean scores

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Table 4.6
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Non-SSEP students' interest in science careers mean scores

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Table 4.7
Paired t-test
Comparison of SSEP students' science attitude mean scores, pre/post

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Table 4.8
Paired t-test
Comparison of SSEP students' interest in science careers mean scores, pre/post

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### Table 4.9
Two sample t-test
Comparison of SSEP students and students who applied but were not accepted post science attitude mean scores

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<th>Std. Err</th>
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<tr>
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<td>.674</td>
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### Table 4.10
Two sample t-test
Comparison of SSEP students and students who applied but were not accepted post interest in science careers mean scores

<table>
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**Means Table**

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<th>Std. Err</th>
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<tr>
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Table 4.11
ANOVA Table
Effect: gender * pre/post
Non-SSEP students’ science attitude mean scores

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Means Table

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<th>Std. Err.</th>
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<td>.048</td>
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<td>.840</td>
<td>.069</td>
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Table 4.12
ANOVA Table
Effect: gender * pre/post
Non-SSEP students' interest in science careers mean scores

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Means Table

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<th>Std. Err.</th>
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<td>9.509</td>
<td>.536</td>
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ANOVA Table
Effect: pre/post * gender
SSEP students' science attitude mean scores

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Means Table

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<tr>
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<tr>
<td>F, post SA</td>
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<td>.792</td>
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<tr>
<td>M, pre SA</td>
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<td>.942</td>
<td>.616</td>
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<td>M, post SA</td>
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<td>.832</td>
<td>.668</td>
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Table 4.14
ANOVA Table
Effect: pre/post * gender
SSEP students' interest in science careers mean scores

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<th>P-Value</th>
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Means Table

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<tr>
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<tr>
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Table 4.15
ANOVA Table
Effect: Ethnicity * pre/post
Non-SSEP students' science attitude mean scores

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<th>P-Value</th>
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<td>Ethnicity</td>
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<td>*</td>
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Means Table

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<td>.812</td>
<td>.056</td>
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<td>.252</td>
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<td>.410</td>
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<td>NatAm, post</td>
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<td>*</td>
<td>*</td>
<td>*</td>
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<td>AfrAm, pre</td>
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<td>1.141</td>
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Table 4.16
ANOVA Table
Effect: Ethnicity * pre/post
Non-SSEP students' interest in science careers mean scores

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Means Table

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Table 4.17
ANOVA Table
Effect: pre/post * Ethnicity
SSEP students' science attitude mean scores

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Fisher's PLSD
Significance Level: 5 %

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Table 4.18
ANOVA Table
Effect: pre/post * Ethnicity
SSEP students' interest in science careers mean scores

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<th>P-Value</th>
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Means Table

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<th>Std. Err.</th>
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<tr>
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Table 4.19
ANOVA Table
Effect: City * pre/post
Non-SSEP students' science attitude mean scores

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Table 4.20
ANOVA Table
Effect: City * pre/post
Non-SSEP students' interest in science careers mean scores

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Table 4.21
ANOVA Table
Effect: pre/post * City
1993 & 1994 SSEP students' science attitude mean scores

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<td>H, post SA</td>
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Fisher's PLSD
Significance Level: 5 %

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Table 4.22
ANOVA Table
Effect: pre/post * City
1993 & 1994 SSEP students' interest in science careers mean scores

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Fisher's PLSD
Significance Level: 5 %

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Table 4.23
ANOVA Table
Effect: pre/post * pre Grade
SSEP students' science attitude mean scores

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Table 4.24
ANOVA Table
Effect: pre/post * pre Grade
SSEP students' interest in science careers mean scores

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ANOVA Table
Effect: pre/post * Year attended camp
SSEP students’ science attitude mean scores

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Table 4.26
ANOVA Table
Effect: pre/post * Year attended camp
SSEP students’ interest in science careers mean scores

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ANOVA Table
Effect: pre/post * Interview
SSEP students' science attitude mean scores

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<td>47.223</td>
<td>.656</td>
<td></td>
<td></td>
</tr>
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<td>Category for SA</td>
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<tr>
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<tr>
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<td>72</td>
<td>27.212</td>
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</table>

Means Table

<table>
<thead>
<tr>
<th>Count</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes, pre SA</td>
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<td>.905</td>
<td>.675</td>
</tr>
<tr>
<td>yes, post SA</td>
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<td>.970</td>
<td>.602</td>
</tr>
<tr>
<td>no, pre SA</td>
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<td>.699</td>
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<tr>
<td>no, post SA</td>
<td>56</td>
<td>.707</td>
<td>.782</td>
</tr>
</tbody>
</table>

Table 4.28
ANOVA Table
Effect: pre/post * Interview
SSEP students' interest in science careers mean scores

<table>
<thead>
<tr>
<th>Effect</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-Value</th>
<th>P-Value</th>
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</thead>
<tbody>
<tr>
<td>Interview</td>
<td>1</td>
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<td>89.596</td>
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<tr>
<td>Subject (Group)</td>
<td>72</td>
<td>6887.329</td>
<td>95.657</td>
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</tr>
<tr>
<td>Category for CDM</td>
<td>1</td>
<td>262.223</td>
<td>262.223</td>
<td>5.235</td>
<td>.0251</td>
</tr>
<tr>
<td>Category for CDM * Interview</td>
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<td>61.460</td>
<td>61.460</td>
<td>1.227</td>
<td>.2717</td>
</tr>
<tr>
<td>Category for CDM * Subject</td>
<td>72</td>
<td>3606.817</td>
<td>50.095</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means Table

<table>
<thead>
<tr>
<th>Count</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes, pre Science</td>
<td>18</td>
<td>22.222</td>
<td>7.612</td>
</tr>
<tr>
<td>yes, post Science</td>
<td>18</td>
<td>21.833</td>
<td>7.808</td>
</tr>
<tr>
<td>no, pre Science</td>
<td>56</td>
<td>21.911</td>
<td>7.581</td>
</tr>
<tr>
<td>no, post Science</td>
<td>56</td>
<td>18.518</td>
<td>9.828</td>
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</table>
CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Changes Over Time

The comparison of non-SSEP students' science attitude data from 1992-1994 with data from 1996-1997 indicated that at both times high school students from Holyoke and Chicopee had a lower interest in science than middle school students. While there was a statistically significant decrease in students' interest in science from 1992-1994 to 1996-1997 for both middle and high school students, the data shows that overall both groups' interest in science was low at both times. A similar downward trend in students' interest in science was observed for SSEP students as they moved from junior to senior high school.

This does not seem surprising when one thinks about the approach to science teaching that is used at the different levels. My personal experience as a PALMS (Partnership Advancing the Learning of Math and Science) consultant, working with science educators K-12 across the state of Massachusetts, has shown me that in general, junior high school science teachers are more apt to use a hands-on inquiry-based approach in helping students learn science than high school teachers. In contrast, I have found that many high school science teachers still use traditional methods, lectures and note taking, as a means to teach science to students.

The interviews conducted with SSEP students revealed that some students don't like science when it is taught in a fashion where they are expected to take notes and memorize information. Students said in the
interviews that they preferred hands-on inquiry-based science. When science is taught using an inquiry-based approach, students are interested in science. This, in turn, motivates them to put more effort into the subject. The interviews uncovered students’ opinions about learning and doing science. I believe that students’ perspectives should be listened to and taken seriously. Students know what makes learning science interesting.

**The Long-Term Impact of SSEP**

While it was useful to compare SSEP students to non-SSEP students, it is important to note that they were not comparable groups of students. Students who went to the SSEP were not like their peers. SSEP students’ attitude towards science and interest in science careers were much higher than those of students who did not apply to the program. However, this study revealed that students who did apply to the program, but were not accepted, did have a high interest in science like SSEP students.

The comparison between students who applied but were not accepted, and students who went to camp, indicated that over the years, SSEP students maintained a more positive attitude towards science and a higher interest in science careers. In contrast, students who applied and were not accepted showed a decrease in attitude towards science and interest in science careers over time, compared to SSEP students. These findings suggest that the program had a positive long-term impact on SSEP students’ attitude towards science and interest in science careers.

Attending SSEP may have helped students maintain a high interest in science. Perhaps SSEP acted like a "booster shot". SSEP students started off with a high interest in science and it appears that the science camp experience may have helped them maintain that high level of interest.
What is it about the program that might help explain why SSEP students maintained a high interest in science? The pedagogy that was used during summer camp may help explain these findings. Students who participated in SSEP were actively engaged in science using a hands-on inquiry-based approach. The interviews suggest that this is what made science not only enjoyable but also interesting for students. In addition, the interviews with SSEP students indicated that students prefer hands-on inquiry-based science. They stated that this active approach to science is more engaging than sitting and listening to teachers.

Perhaps SSEP reinforced that science could be fun and interesting to do. As stated above, the SSEP students experienced hands-on inquiry-based science, which may have helped them maintain their high level of interest. By contrast, the students who applied but were not accepted, may have been only exposed to traditional methods of science instruction such as lecturing and note taking.

A possible explanation for the observed decrease in both SSEP and non-SSEP students' interest in science from the time they were in junior high to the time they were in senior high may be the use of traditional methods of science teaching at the high school level. The interviews suggest that students may lose interest in science because of the way their science classes were taught. Some students stated they were "turned off" by learning science through traditional methods which merely included lectures and note taking.

The Long-Term Goal of SSEP

The long-term goal of SSEP was to increase students' interest in science and science careers, in particular among females and students of color. However, SSEP students came to camp with a high interest in science. The
surveys indicated that the program did not, across the board, increase students’ interest in science. The original goal may have been unrealistic. At this time, the data suggest that you may not be able to take students with a high interest in science and make them more interested in science because of a ceiling effect. That is, while the program does not appear to have increased students’ interest in science, it appears that the program may have had a positive long-term impact on students’ interest in science (i.e., SSEP helped students maintain a high level of interest in science).

**Impact of SSEP on Females and Students of Color**

The surveys indicated that there were no statistically significant differences between female and male SSEP students’ interest in science. However, the survey data revealed that SSEP females’ attitude towards science and interest in science careers showed a slightly greater downward trend than SSEP males’. In traditional science classrooms students work in isolation in a competitive environment. The structure of traditional science classrooms may affect females’ attitudes towards science and interest in science careers more than males’. Belenky, Clinchy, Goldberger and Tarule (1986) assert that females’ self-concepts and ways of learning are intertwined. They argue that females learn through connectedness. Traditional science classrooms may decrease females’ interest in science, as students are isolated from teachers and other students. Overall, it is important to note that both female and male SSEP students’ had a high interest in science pre and post in comparison to non-SSEP students. Both male and female SSEP students maintained a high level of interest in science over the time period studied.

The surveys indicated that there were statistically significant differences in SSEP students’ attitude towards science among the different ethnicities.
White SSEP students had a more positive attitude towards science than African-American SSEP students. This difference was attributed to the way students were recruited to participate in the program. While white SSEP students may have started off with a more positive attitude towards science than African-American SSEP students, the surveys indicated that both groups maintained a higher level of interest in science over time than non-SSEP students.

Overall, the surveys indicated that SSEP had the same positive impact on all students. Enrichment programs like SSEP may help middle school students with a high interest in science maintain that interest over time. If the goal of an enrichment program is to attract people of color and women to science, then according to this study, one needs to find students of color and females with a high interest to begin with. If at the middle school level students of color and females do not have a high interest in science, then one may want to intervene earlier in their education to prevent this situation.

**Summary**

This longitudinal study provides evidence that a two week summer science program which used an inquiry-based approach may have helped middle school students with a high level of interest in science maintain a high level of interest in science during their years in high school.

Poor science teaching may cause some students to leave science. In Talking About Leaving: Why Undergraduates Leave the Sciences, Seymore and Hewitt (1997) reported that poor science teaching was the most common complaint (83%) cited by all undergraduate students. They also found that the most effective way to retain underrepresented students (women and students of color) is to improve the quality of the learning experience. It is of extreme
importance that today's science educators focus their attention on the body of knowledge about how people learn. The approach that teachers use to help students learn is an important factor that affects students' interest level. With increasing diversity in science classrooms, teachers must be aware and able to use a variety of teaching methods which enable all students to learn because a diverse population of students contains students who have different cognitive styles. Traditional methods of instruction may not be as effective with underrepresented groups in science as hands-on, inquiry-based methods.

It is apparent from the interviews that students are willing to exert more effort in science classes if they are interested in the material being covered. Based on many years of experience in a science classroom, I would conjecture that if students are highly interested they are more likely to do well and receive better grades which reinforces their interest in the subject. If their interest remains high perhaps they are more likely to go on and major in science at the college level.

**Recommendations for Future Studies**

This study indicated that SSEP, an inquiry-based science program, helped middle school students who participated (females and students of color included) maintain a high interest in science for several years. In contrast, the interest in science of students who applied but were not accepted decreased over time. Further research is needed to learn more about what causes students to lose interest in science as they go from junior to senior high school.

Research that compares this program to other inquiry-based programs would be enlightening, regarding factors, circumstances and environments that help students maintain a high interest in science. Questions to investigate
might include: 1) What worked for one program but not another? or 2) What commonalities exist in spite of different settings?

Additional studies are needed that follow students for longer periods of time. We need to study the impact that inquiry-based science programs designed for middle school students have on students' majors in college as well as on their career choices.

This study looked at the impact of an inquiry-based program on middle school students' interest in science. Further studies are needed that look at the long-term impact inquiry-based science programs have on students from different levels of education, such as elementary, high school and college students.

In this study non-SSEP populations at the junior high and high school level may not have been comparable groups. Junior high school classes that completed the surveys were composed of heterogeneous mixtures of students; tracking was not done at the junior high school level in the cities that participated in this study. However, all the high schools that participated in this study had different level tracks for students. The high school classes that completed the surveys were composed of standard level students. Thus, further studies should be designed using populations that are comparable.

This study focused on a summer science camp program which used an inquiry-based approach. Another recommendation for further research is to investigate the long-term impact of inquiry-based science programs which are conducted in school classrooms.

The interviews conducted with SSEP students revealed that students felt that teachers greatly influenced their attitude towards science and interest in science careers. Further investigations should be conducted which study the impact of teachers on students' attitude towards science.
The data indicated that students with a high interest in science benefited from this type of program. However, further studies should look at the impact inquiry-based science programs have on students with little or no interest in science.

This study was particularly focused on the impact of an inquiry-based science program on groups of students who are underrepresented in science (females and students of color). Further research using qualitative methods may help uncover females' and students' of color perspectives about learning science using an inquiry-based approach.

And lastly, while SSEP (an inquiry-based science program) helped students with a high interest in science maintain that interest over time, further studies should look to see if there is any correlation between students' interest in science and their understanding of science.
APPENDIX A

SCIENCE OPINION SURVEY,
CAREER DECISION-MAKING REVISED SURVEY
AND
STUDENT INFORMATION SHEET
<table>
<thead>
<tr>
<th>Statement</th>
<th>I strongly agree</th>
<th>I agree</th>
<th>I'm not sure</th>
<th>I disagree</th>
<th>I strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Science lessons are fun</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>2. I would dislike being a scientist after I leave school.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>3. I would like to take another science course.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>4. I dislike science lessons.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>5. When I leave school, I would like to work with people who make discoveries in science.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>6. I will be glad when I am done taking science classes.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>7. School should have more science lessons each week.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>8. I would dislike a job in a science laboratory after I leave school.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>9. I would like to learn more about science.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>10. Science lessons bore me.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>11. Working in a science laboratory would be an interesting way to earn a living.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>12. I would be wasting my time if I took more science courses.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>13. Science is one of the most interesting school subjects.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>14. A career in science would be dull and boring.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>15. I will miss taking science courses in the future.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>16. Science lessons are a waste of time.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>17. I would like to teach science when I leave school.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>18. I do not want to take any more science classes.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>19. I really enjoy going to science lessons.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>20. A job as a scientist would be boring.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>21. Additional science courses are not a waste of time.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>22. The material covered in science lessons is uninteresting.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>23. A job as a scientist would be interesting.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>24. Science courses I take in the future will be boring.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>25. I look forward to science lessons.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>26. I would dislike becoming a scientist because it needs too much education.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>27. Science classes I take in the future will be interesting.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>28. I would enjoy school more if there were no science lessons.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>29. I would like to be a scientist when I leave school.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>30. I do not need to learn more science.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
</tbody>
</table>
CAREER DECISION-MAKING REVISED SURVEY

Circle **L** if you LIKE the activity.
Circle **?** if you ARE NOT SURE.
Circle **D** if you DISLIKE the activity.

1. **L** ? **D** Fix watches and jewelry
2. **L** ? **D** Make furniture and cabinets
3. **L** ? **D** Fix things around the house
4. **L** ? **D** Be an electrician
5. **L** ? **D** Perform scientific studies
6. **L** ? **D** Read books or magazines about science
7. **L** ? **D** Be a doctor who specializes in preventing diseases
8. **L** ? **D** Do scientific studies of the sun, moon, planets, and stars
9. **L** ? **D** Sing on stage
10. **L** ? **D** Be an artist
11. **L** ? **D** Take music courses
12. **L** ? **D** Write a novel
13. **L** ? **D** Ask people about community problems
14. **L** ? **D** Help people with physical problems train for a job
15. **L** ? **D** Teach in an elementary school or high school
16. **L** ? **D** Study how people live together
17. **L** ? **D** Run a large office building
18. **L** ? **D** Buy goods for a large department store
19. **L** ? **D** Make money by trading on the stock market
20. **L** ? **D** Run a large restaurant
21. **L** ? **D** Be a bank teller
22. **L** ? **D** Keep the financial records for a company
23. **L** ? **D** Run business machines in an office
24. **L** ? **D** Be an accountant who prepares tax returns

25. **L** ? **D** Drive a large truck
26. **L** ? **D** Refinish furniture
27. **L** ? **D** Put in and fix telephones
28. **L** ? **D** Work on a construction job
29. **L** ? **D** Use math to solve technical and scientific problems
30. **L** ? **D** Invent scientific equipment
31. **L** ? **D** Do research on using the sun’s energy to heat homes
32. **L** ? **D** Work to develop an artificial heart
33. **L** ? **D** Be a jazz musician
34. **L** ? **D** Read about music or art
35. **L** ? **D** Design ads for TV or magazines
36. **L** ? **D** Write newspaper articles
37. **L** ? **D** Give legal advice to poor people
38. **L** ? **D** Help children with mental problems
39. **L** ? **D** Teach or train adults
40. **L** ? **D** Help people choose their careers, the kind of work they want to do
41. **L** ? **D** Hold public office, for example, be a mayor or senator
42. **L** ? **D** Be a lawyer for a company
43. **L** ? **D** Hold a leadership position
44. **L** ? **D** Be a real estate agent showing and selling houses
45. **L** ? **D** Keep records of goods in stock and supplies received
46. **L** ? **D** Work with numbers in a business office
47. **L** ? **D** Pay a company’s bills
48. **L** ? **D** Check bank reports for mistakes
Circle L if you LIKE the activity.
Circle ? if you ARE NOT SURE.
Circle D if you DISLIKE the activity.

49. L ? D Fix car engines
50. L ? D Build book shelves
51. L ? D Build houses as a building contractor
52. L ? D Carve animals out of wood
53. L ? D Be a medical lab assistant
54. L ? D Take a biology course
55. L ? D Study how to control plant and crop diseases
56. L ? D Do research work in a physics lab
57. L ? D Write a one-act play
58. L ? D Write or arrange music
59. L ? D Be a radio announcer
60. L ? D Design scenery for plays
61. L ? D Do probation work with people who have broken the law
62. L ? D Plan activities for others
63. L ? D Give first aid to people in need
64. L ? D Work as a marriage or family counselor
65. L ? D Work to convince Congress to pass a law
66. L ? D Be a leader in the building of a shopping mall
67. L ? D Make a trade or bargain
68. L ? D Be a judge
69. L ? D Take a business math course
70. L ? D Use computers to keep bookkeeping records
71. L ? D Take an accounting course
72. L ? D Use a keyboard to enter information into a computer
73. L ? D Work as a wildlife officer
74. L ? D Be a carpenter
75. L ? D Deliver packages to homes and businesses
76. L ? D Repair computers
77. L ? D Do scientific studies about nature
78. L ? D Help research scientists in their lab experiments
79. L ? D Develop ways to make sure the water supply is clean
80. L ? D Be a space scientist
81. L ? D Arrange the background music for movies
82. L ? D Be a newspaper photographer
83. L ? D Write stories for TV
84. L ? D Listen to the works of great musicians
85. L ? D Help people find jobs after they leave prison
86. L ? D Teach and help people in poor countries
87. L ? D Study how and why people behave the way they do
88. L ? D Teach in a playground sports program
89. L ? D Find and hire people to work for a large company
90. L ? D Travel all over the country selling goods to companies
91. L ? D Be a business leader
92. L ? D Be in charge of making products
93. L ? D Keep a record of how much money each worker should get
94. L ? D Assign rooms at the main desk of a hotel or motel
95. L ? D Run data processing (computer) equipment
96. L ? D Write computer programs
STUDENT INFORMATION SHEET

Your Initials: ____________  Today's Date: ____________

Any information you provide to us will be kept confidential and will only be used in our research. Your teachers and principal will not see your responses! Thanks for participating!

Date of Birth: __________ __________ __________
month  day  year

Gender: (circle one)
Female  Male

Ethnic Group: (circle any which apply)
African American  Native American
Asian American  White
Hispanic  Other

Grade Level: (circle one)
6  7  8  9  10  11  12
APPENDIX B

CONSENT TO ACT AS RESEARCH SUBJECT
AND
LETTERS TO STUDENTS
EVALUATION STUDY OF THE SUMMER SCIENCE EXPLORATION PROGRAM (SSEP) AT HAMPSHIRE COLLEGE

SSEP was a summer science enrichment program offered by Hampshire College. This evaluation is designed to learn more about the long term impact, if any, of the program on students' attitudes towards science and science related careers.

CONSENT FOR VOLUNTARY PARTICIPATION

I volunteer to participate in this qualitative study and understand that:

1. I will be interviewed by Helen Gibson using a semi-structured interview format.
2. The questions I will be answering address my views on issues relating to the SSEP.
3. The interview will be tape recorded to facilitate analysis of data. The collected data will consist of survey data as well as interview data.
4. My name will not be used, nor will I be identified personally in any way at any time. I understand that it will be necessary to identify participants in publications, including Helen Gibson's dissertation, by gender, ethnicity, grade level and school system (e.g. a female, African American, junior from Holyoke).
5. I may withdraw from part or all of this study at any time.
6. I have the right to review material prior to Helen Gibson's final oral exam or other publication.
7. The results from this study will be included in Helen Gibson's doctoral dissertation as well as in other publications and presentations. Results may also be included in manuscripts submitted to professional journals for publication.
8. The projected benefits of the study include suggestions for improvement of science enrichment programs such as the SSEP which may impact science instruction in schools.
9. I am free to participate or not without prejudice.
10. Because of the small number of participants, approximately twenty, there is some risk that I may be identified as a participant in this study.
11. I may obtain a copy of the results of this study from Helen Gibson once it is completed.

Please feel free to ask any questions before signing the consent form. You will receive a copy of this form to keep for future reference.

Participant is a minor, age

Participants Signature________________________ Date
Parent/ Guardian Signature________________________ Date

Helen Gibson's Signature________________________ Date
Doctoral Student, School of Education
University of Massachusetts, Amherst, MA 01003
Dear Student,

You participated in the Summer Science Exploration Program (SSEP) at Hampshire College several years ago. We are now conducting an evaluation which is designed to learn more about the long term impact, if any, of the program on students' attitudes towards science and science related careers.

I am writing to ask you to participate in a research study I am conducting for Hampshire College. Please fill out the following two enclosed surveys: the Science Attitude Survey and the Career Decision Making-Revised Survey.

Please fill out the consent form for voluntary participation and return it along with the surveys in the envelope provided.

I will be happy to answer any questions you may have regarding my research. Thank you for your cooperation and permission.

Sincerely,

Helen Gibson, M.Ed.
Doctoral Student
School of Education
University of Massachusetts
Amherst, MA 01003

phone: 413-367-9457
email address: helen@educ.umass.edu
EVALUATION STUDY OF THE SUMMER SCIENCE EXPLORATION PROGRAM (SSEP) AT HAMPshire COLLEGE

SSEP was a summer science enrichment program offered by Hampshire College. This evaluation is designed to learn more about the long term impact, if any, of the program on students’ attitudes towards science and science related careers.

CONSENT FOR VOLUNTARY PARTICIPATION

I volunteer to participate in this quantitative study and understand that:

1. I will be asked to fill out two surveys: the Science Attitude Survey and the Career Decision-Making Survey.
2. My name will not be used, nor will I be identified personally in any way at any time. I understand that it will be necessary to identify participants in publications, including Helen Gibson’s dissertation, by gender, ethnicity, grade level and school system (e.g. a female, African American, junior from Holyoke).
3. I may withdraw from part or all of this study at any time.
4. I have the right to review material prior to Helen Gibson’s final oral exam or other publication.
5. The results from this study will be included in Helen Gibson’s doctoral dissertation as well as in other publications and presentations. Results may also be included in manuscripts submitted to professional journals for publication.
6. The projected benefits of the study include suggestions for improvement of science enrichment programs such as the SSEP which may impact science instruction in schools.
7. I am free to participate or not without prejudice.
8. I may obtain a copy of the results of this study from Helen Gibson once it is completed.

Enclosed are two copies of this form. Please keep a copy of this form for future reference.

Participant is a minor, age

Participants Signature_________________________ Date

Parent/ Guardian Signature_________________________ Date

Helen Gibson
Doctoral Student
School of Education
University of Massachusetts
Amherst, MA 01003
Dear student,

Some students from your school district participated in a Summer Science Exploration Program (SSEP) offered by Hampshire College from 1992-1994. I am now conducting a research project designed to learn more about the long term impact, if any, of the program on students’ attitudes towards science and science related careers.

I am asking you to fill out two surveys: the Science Attitude Survey and the Career Decision-Making Survey.

You are free to participate or not without prejudice. Your name will not be used, nor will you be identified personally in any way at any time. You may withdraw from part or all of this study at any time.

You have the right to review material prior to Helen Gibson’s final oral exam or other publication. The results from this study will be included in Helen Gibson’s doctoral dissertation as well as in other publications and presentations. Results may also be included in manuscripts submitted to professional journals for publication. You may obtain a copy of the results of this study from Helen Gibson once it is completed.

The projected benefits of the study include suggestions for improvement of inquiry-based science enrichment programs such as the SSEP which may impact science instruction in schools.

Your informed consent to participate in the study under the conditions described above is assumed by your completing the questionnaire and submitting it to the researcher. Do not complete the questionnaire or hand it in if you do not understand or agree to these conditions.

Helen Gibson
Doctoral Student
School of Education
University of Massachusetts
Amherst, MA 01003
February 5, 1997

Dear Student,

On December 30, 1996 I sent you the enclosed surveys. However, I have not received the surveys from you yet. I am sending you a second copy and hope that you can find the time to fill them out and return them as soon as possible. It is very important that we get these surveys from as many students as possible.

You participated in the Summer Science Exploration Program (SSEP) at Hampshire College several years ago. We are now conducting an evaluation which is designed to learn more about the long term impact, if any, of the program on students’ attitudes towards science and science related careers.

I am writing to ask you to participate in a research study I am conducting for Hampshire College. Please fill out the following two enclosed surveys: the Science Attitude Survey and the Career Decision Making-Revised Survey.

Please fill out the consent form for voluntary participation and return it along with the surveys in the envelope provided.

I will be happy to answer any questions you may have regarding my research. Thank you for your cooperation and permission.

Sincerely,

Helen Gibson, M.Ed.
Doctoral Student
School of Education
University of Massachusetts
Amherst, MA 01003

phone: 413-367-9457
email address: helen@educ.umass.edu
October 1, 1996

Dear Student,

Dr. Christopher Chase of Hampshire College and his Research Associate Helen L. Gibson are conducting interviews with students who participated sometime between 1992 to 1994 in the Summer Science Exploration Program at Hampshire College. The goal of their study is to learn more about the long term impact of this program and how it may have influenced students’ attitudes toward science and interest in science careers.

If you agree to participate, you may be interviewed and or asked to complete some questionnaires. The interview and questionnaires will cover topics related to the Summer Science Exploration Program, school, and career interest. About one hour will be needed for the interview which will be tape recorded. An additional 10 to 15 minutes will be needed for the questionnaires.

Research records will be kept confidential and individual privacy will be maintained in published and written data. There are no risks from participating in this study, however, the study will help us understand more about the positive and negative impact of programs such as these.

Please check one of the following:

_____I am willing to be interviewed and fill out the questionnaires.

_____I am only willing to fill out the questionnaires.

Student's Name: __________________________________________

Address: ________________________________________________

Telephone Number: ________________________________________

______________________________ __________________________
Student Signature Date

______________________________ __________________________
Parent Signature Date

185
May 2, 1997

Dear Student,

I am writing to ask you to participate in a research study I am conducting for Hampshire College. We are interested in learning about high school students' attitudes towards science and interest in various careers.

Please fill out the two enclosed surveys: the Science Attitude Survey and the Career Decision Making-Revised Survey. I can assure you that your name will not be used, nor will you be personally identified in any way at any time.

It is very important that we get these surveys from as many students as possible. Please return the surveys in the envelope provided by May 16th.

I will be happy to answer any questions you may have regarding my research. Thank you for your cooperation and permission.

Sincerely,

Helen Gibson, M.Ed.
Doctoral Student
School of Education
University of Massachusetts
Amherst, MA 01003

phone: 413-367-9457
email address: helen@educ.umass.edu
IMPORTANT: 2ND NOTICE

May 23, 1997

Dear Student,

On May 2nd, 1997 I sent you the enclosed surveys and asked you to participate in a research study I am conducting about high school students' attitudes towards science and interest in various careers. However, I have not received the surveys from you yet. I am sending you a second copy and hope that you can find 15-20 minutes to fill them out and return them by June 7th. It is very important that we get these surveys from as many students as possible.

Please fill out the two enclosed surveys: the Science Attitude Survey and the Career Decision Making-Revised Survey and return the surveys in the envelope provided. I can assure you that your name will not be used, nor will you be personally identified in any way at any time.

I will be happy to answer any questions you may have regarding my research. Thank you for your cooperation and permission.

Sincerely,

Helen Gibson, M.Ed.
Doctoral Student
School of Education
University of Massachusetts
Amherst, MA 01003

phone: 413-367-9457
email address: helen@educ.umass.edu
APPENDIX C

ETHNICITY AND GENDER OF SSEP STUDENTS
Ethnicity & Gender of SSEP students

- 81 white female
- 48 white male
- 38 Afr Am female
- 36 African Am male
- 29 B Hisp female
- 29 Hi Hisp male
- 25 As Am female
- 24 As Am male
- 189 NA/other
BIBLIOGRAPHY


American Association for the Advancement of Science. (September/October 1996). Organizations unite to promote access and equity. Science Education News, 14(5).


