The Effects of Field Trips on Attitudes toward Science

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Executive Summary

The Science and Environment Council of Sarasota County (SEC), in collaboration with the Sarasota County School Board, piloted a new Science Curriculum Enhancement Project in the spring of 2007. The purpose of the project was to enhance science curriculum through community-based science education and inquiry-based activities.

The program was designed to give on-level students the opportunity to experience science in their own community, making it relevant to their lives by connecting textbook science concepts to real-world applications, including career paths. To accomplish this, students engaged in inquiry-based activities, lessons, and interaction with science professionals and technicians outside the classroom.

On-level 9th graders were chosen to pilot the project because interest in learning science often declines at this grade level. An integrated science class at Booker High School was selected to participate. Another class of integrated science students taught by the same teacher was selected as a control group (received traditional classroom instruction). A third class of integrated science students taught by the same teacher was selected to receive in-class presentations by SEC staff and thus served as the comparison group.

In April and May 2007, the field trip class participated in six field trips. Each field trip was developed to align with Florida's Sunshine State Science Standards, and focused on a specific topic from the classroom textbook *Glencoe Physical Science with Earth Science*. SEC organizations participating in the program this year are: Lemur Conservation Foundation, Sarasota County Urban Forestry Program, Selby Botanical Gardens, Crowley Museum and Nature Center, Mote Marine Laboratory, and Gulfcoast Wonder and Imagination Zone (G.WIZ).

This evaluation utilized a science attitude survey, field notes, and post-trip surveys to assess the success of SEC's Science Curriculum Enhancement Project in achieving their goal of improving student attitudes toward science.

Results of the Science Attitude Inventory II (SAI II) showed that students who attended the field trips demonstrated consistently better attitudes toward science than students in the control (traditional instruction) or comparison (SEC-in class) conditions, although only the difference between the field trip and comparison groups was statistically significant. This finding was seen on the overall total scale of the SAI II, as well as the composite positive subscale and two individual subscales (5-A and 6-A).

The evidence – both quantitative and qualitative – indicates that field trips increase students' attitude toward and possibly interest in science and provide a useful pedagogical tool that allows more student interaction with positive role models in the various scientific disciplines. It is apparent from these findings that multiple science-related field trips further develop student engagement and help students develop connections from one trip to the next as well as between the concepts they are studying in class and the real world. The changes seen in the students who attended the field trips are not mirrored in either the control group (traditional instruction) or the comparison group (SEC-in class presentation). The results are even more compelling in that the comparison group (SEC-in class presentation) consisted of honors students who are traditionally viewed as excelling in science and presumably have a more positive attitude toward science.

INTRODUCTION

Science curriculum, instruction, and achievement are finding themselves in the spotlight in American education as continued public concerns of falling behind internationally coincide with the No Child Left Behind Act's (2001) science requirement and standards-based science assessments.

A variety of research has examined attitudes and achievement. A positive attitude toward science appears to be very beneficial to, if not necessary for achievement in science, especially for girls (Jarvis and Pell 2005). Further, abundant research shows a decline in attitudes towards science beginning in the secondary grades (approximately age eleven) (Osborne, 2003).

As a result, it has become prudent for school districts to examine their science curriculum and to look for ways to improve science attitudes as a means of improving science achievement. Science is a content area that many students need to explore in person through the various senses rather than read about in a textbook. A recent study by Turpin & Cage (2004) demonstrated that an activity-based approach to science improves secondary students' achievement in science. While many high school science classes have a laboratory component, many educators agree that seeing science first hand out in the 'real world' raises the curriculum to a whole new level.

Jarvis and Pell (2005) indicate that "science centers can address aspects of science education that might be missing in more formal, class-based science learning, to provide an awareness of the relevance of science to society. They can also generate a sense of wonder, interest, enthusiasm, motivation, and eagerness to learn, which are much neglected in traditional formal school science (Pedretti, 2002; Ramey-Gassert, Walberg, & Walberg, 1994)." (p. 53).

"[Science] attitudes do not consist of a single unitary construct, but rather consist of a large number of subconstructs all of which contribute in varying proportions towards an individual's attitudes towards science." (p. 1054). Perhaps the best way to think about attitude toward science is not as a single construct, but rather as a variety of subconstructs including:

- the perception of the science teacher;
- anxiety toward science;
- the perceived value of science;
- self-esteem at science;
- motivation towards science;
- enjoyment of science;
- attitudes of peers and friends towards science;
- attitudes of parents towards science;
- the nature of the classroom environment;
- achievement in science; and
- fear of failing course (Osborne, 2003).

How is this attitude formulated? Attitude toward science has been shown to depend on several key factors: gender, social class, attitudes of friends/peers, classroom/teacher variables, curriculum variables, perceived difficulty of science, and enhanced subject choice (Osborne, 2003).

Another problem is that it is difficult to measure attitude toward science. Some studies have had students rank subjects to determine how they rank science classes in relation to their other classes. Other researchers have utilized attitude scales, interest surveys, class enrollment, or qualitative methods. Each method has some benefits and some drawbacks (Osborne, 2003). For the current study, with the short period of time that existed between the first and last field trips, and the timeframe in which the evaluation was to be completed, looking at course enrollment and ranking of subjects was not viable. Interest inventories are too limited for the purposes of this study, as they have a very specific focus. As a result, attitude scales and qualitative methods were chosen to investigate students' attitude toward science.

SCIENCE CURRICULUM ENHANCEMENT PROJECT

A. Background

The Science and Environment Council of Sarasota County (SEC), in collaboration with the Sarasota County School Board, piloted a new Science Curriculum Enhancement Project in the spring of 2007. SEC's mission is "to promote and advocate science, conservation, and environmental issues in Sarasota County for maintaining and improving quality of life through education, public outreach, demonstration, information gathering and analysis, and special projects."

The purpose of the project was to enhance science curriculum through community-based science education and inquiry-based activities. The project's aim was to make science "real" for students by: (1) showing students how abstract science concepts apply to their community, and (2) providing opportunities for students to interact with people who work in the sciences.

The program was designed to give on-level students the opportunity to experience science in their own community, making it relevant to their lives by connecting textbook science concepts to real-world applications, including career paths. To accomplish this, students engaged in inquiry-based activities, lessons, and interaction with science professionals and technicians outside the classroom.

The program is expected to grow in subsequent years, with expansion to a larger number of students and an increase in participating SEC organizations.

The SEC is a group of non-profit and government organizations that operate or support conservation and science-based facilities. SEC organizations participating in the program this year are: Lemur Conservation Foundation, Sarasota County Urban Forestry Program, Selby Botanical Gardens, Crowley Museum and Nature Center, Mote Marine Laboratory, and Gulfcoast Wonder and Imagination Zone (G.WIZ).

B. Participant Selection

On-level 9th graders were chosen to pilot the project because interest in learning science often declines at this grade level. Elementary and middle school science learning usually involves hands-on activities, field trips, and easily applied concepts. Beginning in 9th grade, more abstract concepts are typically being taught. Outside-the-classroom learning and practical applications of concepts are typically infrequent. It is at this point that many on-level students become disinterested in science.

The Science and Health Program Specialist for Sarasota County Schools recommended Booker High School as a pilot school. The Principal and Assistant Principal at Booker were very enthusiastic about the project and assured successful implementation of the project.

For the pilot year, a team of Booker staff chose one class to participate in the field trip experiences, based on the following criteria:

- 9th grade science class
- on-level students (as opposed to honors or advanced science students)
- class meeting time is convenient for field trips
- teacher is willing participant

Since the teacher who was selected to participate in the Science Curriculum Enhancement Project also teaches two other ninth grade science classes, one of these classes was chosen to be the control class and the other was selected as the comparison class.[1] The control class received traditional science instruction from their teacher, with no contact from SEC staff. The comparison students received in-school presentations from SEC member organizations during their regular science class. These presentations included information concerning the same type of content that the field trip students received.

[1] In an evaluation involving two or more groups, the group that does not receive the full program or treatment is referred to as a comparison group. This group may receive some program, but it is not the main focus of the evaluation. The control group receives no program.

C. Activities

In April and May 2007, the field trip class participated in six field trips. Each field trip was developed to align with Florida's Sunshine State Science Standards, and focused on a specific topic from the classroom textbook *Glencoe Physical Science with Earth Science* (2005). Program evaluation, focused on students' attitude toward science, was an integral part of the Science Curriculum Enhancement Project.

Activities were developed to localize the 9th grade textbook, *Glencoe Physical Science with Earth Science* (2005). These activities presented concepts explored in the textbook in a Sarasota County context by linking new, local activities, with those generic activities offered in the text. Information about jobs in the sciences and skills needed to perform those jobs were included. Two criteria were used to select topics for this first pilot year: (1) students must master the topic, and (2) topics are currently being worked on by SEC members.

In addition, a teacher's component included pre-visit lessons and activities. Teacher feedback was an important evaluation factor.

D. Sites

(1) The *Lemur Conservation Foundation (LCF)* is dedicated to the preservation and conservation of the primates of Madagascar through captive breeding, scientific research, education, and reintroduction.

(2) The *Sarasota County Urban Forestry Program* promotes the use of trees, the benefits of urban trees, and provides educational tools. Staff also provide presentations regarding tree species, tree maintenance, and the benefits of urban trees.

(3) The *Marie Selby Botanical Gardens* fosters understanding and appreciation of tropical plants, especially epiphytes (plants that grow on other plants), through programs of research, conservation, education and display.

(4) *Crowley Museum & Nature Center* preserves a natural site where today's and tomorrow's generations learn about, appreciate, and enjoy the environment and cultural history of the rural Gulf Coast of Florida.

(5) *Mote Marine Laboratory* has expanded from its original focus on sharks to include seven major areas of concentration, organized into seven research centers in Florida. Mote, a global leader in many areas of marine science, is one of the few organizations in the world that combines marine research with public outreach through a full-fledged aquarium.

(6) *Gulfcoast Wonder & Imagination Zone (G.WIZ)* strives to make science relevant, technology understandable, and learning an interactive adventure for people of all ages. There are eighty-five fun and unique hands-on exhibits.

METHOD

A. Purpose of evaluation

This evaluation is designed to assess the success of SEC's Science Curriculum Enhancement Project in achieving their goal of improving student attitudes toward science.

B. Evaluation model

The evaluation utilizes a mixed method approach that includes both quantitative and qualitative data collected from students, teacher, and site personnel. The primary focus of the evaluation is to investigate changes in students' attitudes toward science, as measured by the Science Attitude Inventory II (Moore and Foy, 1997).

The Scientific Attitude Inventory II (SAI-II) was chosen as the most appropriate instrument to measure attitude toward science among ninth-grade science students. The original Scientific Attitude Inventory (SAI) was developed in 1970 and has been used extensively throughout the world (Moore and Sutman, 1970). However, it has become outdated as times have changed in many ways, including issues in science itself and those relating to gender bias. In 1996, the revised version was developed and field-tested. Split-half reliability of the revised instrument is .805 and the Cronbach alpha reliability coefficient is .781. Face validity remains from the original panel of judges (Moore and Foy, 1997). Where appropriate, qualitative data related to students' experiences during the field trips augmented the quantitative findings.

Table 1 illustrates the various subscales that comprise the SAI II instrument. The six individual subscales labeled 1-A through 6-A reflect statements that project science in a positive manner; those labeled 1-B through 6-B reflect negative statements about science. The SAI II consists of 40 total questions with point values from 1 to 5. Thus, the range of possible total scores is 40 to 200. Half of the items are positive and half are negative; the range of possible scores on each of these affective subscales is 20 to 100. Finally, subscales 1-A through 5-A and 1-B through 5-B consist of 3 items each; possible scores on each of these scales range from 3 to 15. Subscales 6-A and 6-B consist of 5 items each, for a possible range of 5 to 25.

Table 1. Subscales of the Science Attitude Inventory II

Positive Scales	Negative Scales
1-A	**1-B**
The laws and/or theories of science are approximations of truth and are subject to change.	The laws and/or theories of science represent unchangeable truths discovered through science.
2-A	**2-B**
Observation of natural phenomena and experimentation is the basis of scientific explanation. Science is limited in that it can only answer questions about natural phenomena and sometimes it is not able to do that.	The basis of scientific explanation is in authority. Science deals with all problems and it can provide correct answers to all questions.
3-A	**3-B**
To operate in a scientific manner, one must display such traits as intellectual honesty, dependence upon objective observation of natural events, and willingness to alter one's position on the basis of sufficient evidence.	To operate in a scientific manner one needs to know what other scientists think; one needs to know all the scientific truths and to be able to take the side of other scientists.
4-A	**4-B**
Science is an idea-generating activity. It is devoted to providing explanations of natural phenomena. Its value lies in its theoretical aspects.	Science is a technology-developing activity. It is devoted to serving mankind. Its value lies in its practical uses.
5-A	**5-B**
Progress in science requires public support in this age of science; therefore, the public should be made aware of the nature of science and what it attempts to do. The public can understand science and it ultimately benefits from scientific work.	Public understanding of science would contribute nothing to the advancement of science or to human welfare; therefore, the public has no need to understand the nature of science. They cannot understand it and it does not affect them.
6-A	**6-B**
Being a scientist or working in a job requiring scientific knowledge and thinking would be a very interesting and rewarding life's work. I would like to do scientific work.	Being a scientist or working in a job requiring scientific knowledge and thinking would be dull and uninteresting; it is only for highly intelligent people who are willing to spend most of their time at work. I would not like to do scientific work.

	C. Design of the evaluation, including sample sizes and timing of data collection

Students' science attitude data were only included in the analyses if they completed both the pre-test and post-test administrations of the SAI II. Additionally, some students failed to report their gender in the demographic portion of the survey, resulting in incomplete demographic information for those students.

Pre- and post-test SAI II data were collected from a total of 49 science students – 19 students (10 female, 8 male, 1 not identified) in the first period class (control group), 18 students (7 female, 11 male) in second period (field trip group), and 12 students (7 female, 4 male, 1 not identified) in third period (comparison/SEC-in class group). Students ranged in age from 14 to 16 years old. The average age of students in the control group was 15.11 years; in the field trip group was 14.89 years; and in the comparison (SEC-in class) group was 14.50 years. All students except for one student (from the field trip group) are in the ninth grade.

	D. Methods of data collection, including description of data collection instruments

<u>Scientific Attitude Inventory II (SAI-II):</u>
Students' pre- and post-trip attitudes toward science were measured for all 3 groups 1 to 2 days prior to the first field trip and during the week following the final field trip. Copies of the SAI II were provided to the teacher, who administered the survey to all students in each class period during regular class time. Care was taken to ensure the anonymity of student data with a numerical coding scheme developed by the teacher.

<u>Field notes:</u>
Extensive field notes regarding all field trip activities, as well as students' reactions, were collected by an individual researcher who attended all of the field trips. The researcher and some site-based personnel recorded students' anonymous comments, questions, and answers. No intrusive methods were used to collect this information; all data was gathered during the natural course of each trip. Students making comments were only identified by their gender; no other identifiable information was collected in the field notes.

<u>SEC Surveys</u>:
Students completed a short post-trip survey developed by SEC at the conclusion of each field trip. The anonymous surveys were pre-coded by the teacher using the same coding scheme as the science attitude surveys to facilitate the compilation of the quantitative and qualitative measures. Survey questions were the same for each field trip:

1. Describe something new you discovered during this field trip.
2. What interested you the most about this field trip?
3. As a result of this field trip, what would you like to know or do now?
4. Did this field trip trigger an interest in a possible career path for you? Describe what that might be.
5. If you could, would you return for another visit?

The completed surveys were initially collected and reviewed by SEC staff, and then they were provided to the researchers at the subsequent field trip. Survey responses were content analyzed to examine the relationship between students' attitudes toward science and their subjective feelings about each of the field trips.

	E. Sources of information and data

Demographic and student achievement data were obtained from the Assistant Principal of the school.

	F. Limitations of the evaluation (e.g., limitations related to methods, data sources, potential sources of bias, etc.)

The limitations of this study are related to the disparate composition of the samples and its effect on the generalizability of the results. While the control and comparison groups were composed of students with the same teacher as the field trip group, the fact that the comparison group was an honors science class introduces an inherent difference in the groups before any field trips took place. A comparison between the students in the honors class and the students in the other classes revealed that the honors class students had higher scores on the prior year's FCAT Reading test than both regular level science classes. While differences on a reading test do not directly reflect differences in the honors students' science ability or achievement, it does demonstrate that there are some inherent differences between the samples, which therefore introduce the possibility of a bias in the evaluation results.

RESULTS

Multiple repeated measure analyses of variance (ANOVA) tests were conducted on the results of the SAI II.[2] Significant ANOVA results were followed up with further statistical tests to elucidate which of the three groups differed statistically from the others. Global measures of students' attitude toward science were examined by a difference score analysis - the mean differences between students' pre-test and post-test scores - on the total scale and on the composite

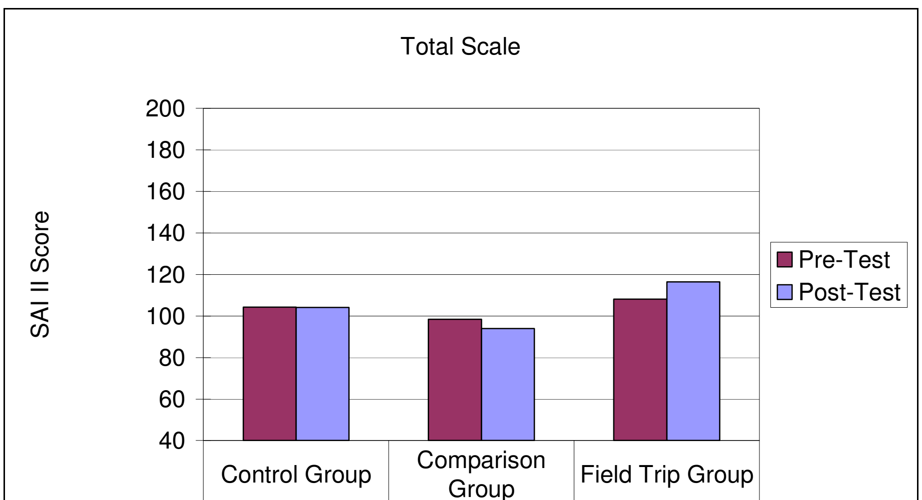
[2] Researchers use this statistical procedure to test differences between means of two or more groups. It is a statistical method for making simultaneous comparisons between two or more means.

affective subscales of the survey instrument. Additional analyses examined mean differences on the six positive and six negative individual subscales. See Table 1 for a description of the constructs that composed each subscale that was utilized in the analyses. See Table 2 for the pre-test and post-test scores on each of the subscales of the SAI II for all three groups.

Total Scale

The results of the overall difference score analysis indicated that students who attended the field trips increased their post-test scores by 8.33, significantly more than students in the comparison/SEC-in class (decrease of 4.55) condition, and more than the control (decrease of 0.14) group, $F(2,31) = 6.36$, $p = .005$.[3] This finding corresponds with the trip chaperones' observations and the students' increased responsiveness to questionnaires given after the field trips. While the initial observations and student responses provided a picture of students who seemed happy just to be out of school for part of the day, the later observations and student responses provided a picture of truly engaged students who responded with more interactive questions and interest in the activities and demonstrations provided on the field trips. See Figure 1 for the average pre-test, post-test, and difference scores of each group on the total scale of the SAI II.

Figure 1. Mean Pre-test, Post-test, and Difference Scores on Total Scale



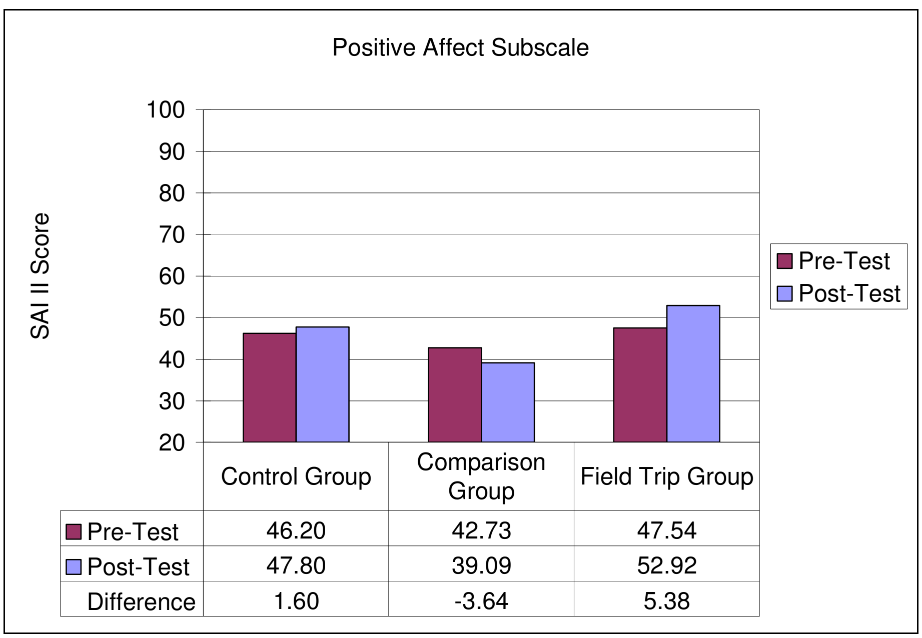
	Control Group	Comparison Group	Field Trip Group
Pre-Test	104.29	98.45	108.11
Post-Test	104.14	93.91	116.44
Difference	-0.14	-4.55	8.33

[3] When employed in the procedure entitled ANOVA, the obtained value of F provides a test for the statistical significance of the observed differences among the means of two or more random samples. Significance, or P-value, is the probability that an effect at least as extreme as the current observation has occurred by chance.

<u>Composite Affective Scales</u>
A composite positive scale for the SAI II was determined by adding up students' scores on each of the six positive individual subscales, i.e. 1-A through 6-A. Similar procedures were used to create a composite negative scale using subscales 1-B through 6-B. Analyses showed significant differences in students' positive attitudes towards science, $F(2,36) = 3.55$, $p = .039$. Students attending field trips increased their scores an average of 5.38 points on the composite positive scale of the SAI II; students in the control group increased their scores by 1.60 points; and the comparison (SEC-in class) group's scores decreased 3.64 points. Follow-up statistical analyses revealed that only the difference between the field trip group and the comparison group (SEC-in class) was significant. No other differences reached statistical significance.

Additionally, no significant differences were noted in students' composite negative scale scores, $F(2,36) < 1$. Taken together with the finding that the students attending field trips had higher overall scores on the SAI II, the lack of a difference in negative attitudes further indicates that the differences were seen at the positive end of the spectrum. See Figure 2 for the average pre-test, post-test, and difference scores of each group on the positive subscale of the SAI II.

Figure 2. Mean Pre-test, Post-test, and Difference Scores on the Positive Subscale



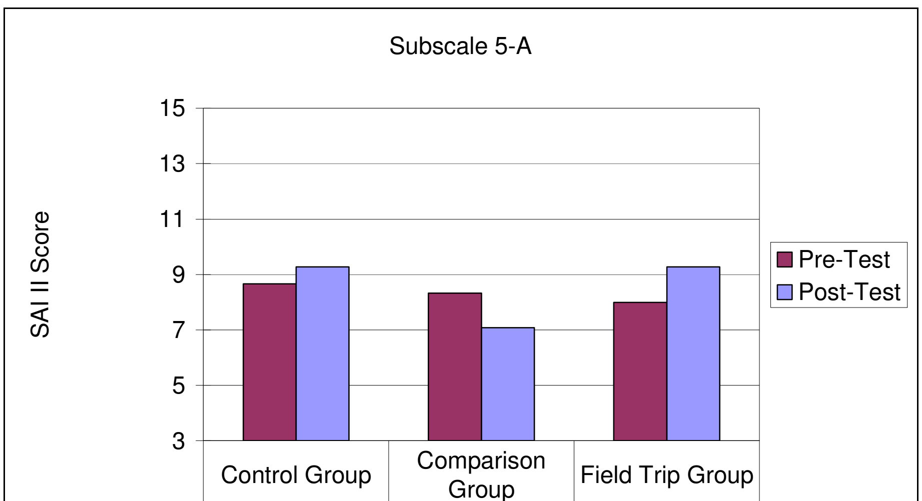
<u>Individual Subscales</u>
When individual subscales (see Table 1) were examined, students in the field trip group had consistently higher differences on two of the positive subscales. No differences were noted on any of the negative subscales.

A significant difference was found between groups on Scale 5-A, $F(2,45) = 3.75$, $p = .031$.

> <u>Scale 5-A:</u> Progress in science requires public support in this age of science; therefore, the public should be made aware of the nature of science and what it attempts to do. The public can understand science and it ultimately benefits from scientific work.

Students attending field trips increased their score an average of 1.28 points on this subscale of the SAI II, compared to an increase of 0.61 for students in the control group, and a decrease of 1.25 points for students in the comparison (SEC-in class) group. Not surprisingly, follow-up analyses revealed that only the difference between the field trip group and the comparison (SEC-in class) was significantly different; no other comparisons reached statistical significance. See Figure 3 for the average pre-test, post-test, and difference scores of each group on subscale 5-A of the SAI II.

Figure 3. Mean Pre-test, Post-test, and Difference Scores on Subscale 5-A



	Control Group	Comparison Group	Field Trip Group
Pre-Test	8.67	8.33	8.00
Post-Test	9.28	7.08	9.28
Difference	0.61	-1.25	1.28

A statistically significant difference was also demonstrated between the field trip and comparison (SEC-in class) groups on Scale 6-A, $F(2,43) = 4.04$, $p = .025$.

> <u>Scale 6-A:</u> Being a scientist or working in a job requiring scientific knowledge and thinking would be a very interesting and rewarding life's work. I would like to do scientific work.

Students attending field trips increased their scores an average of 2.00 points on this subscale of the SAI II, compared to an increase of 1.38 points for students in the control group, and a decrease of 1.17 points for students in the comparison group (SEC-in class). See Figure 4 for the average pre-test, post-test, and difference scores of each group on subscale 6-A of the SAI II.

Figure 4. Mean Pre-test, Post-test, and Difference Scores on Subscale 6-A

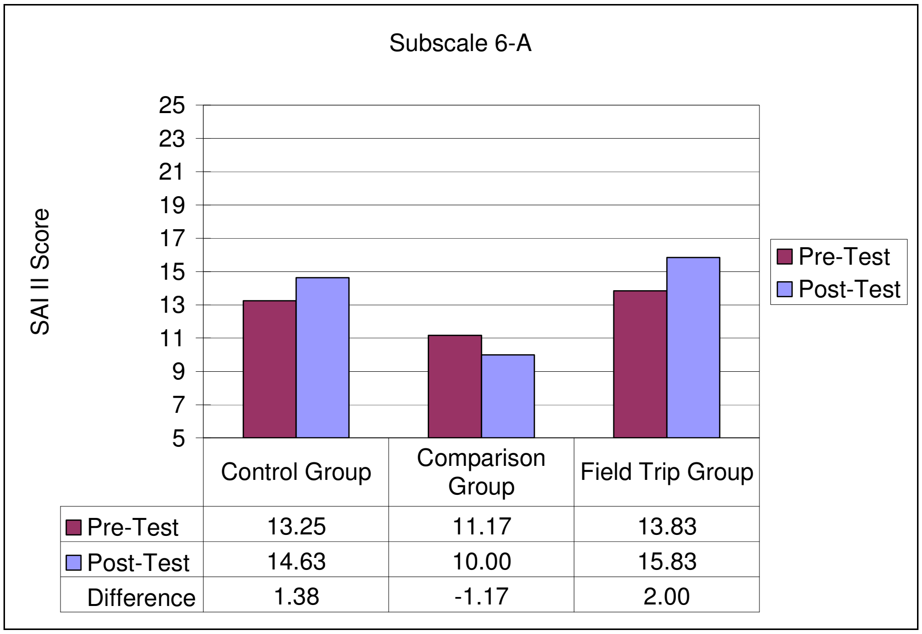


Table 2. All pre-test and post-test scores for every subscale of the SAI II

	Control Group		Comparison Group		Field Trip Group	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
Total	104.29	104.14	98.45	93.91	108.11	116.44
Positive	46.20	47.80	42.73	39.09	47.54	52.92
Negative	58.25	57.19	55.83	54.67	59.91	60.82
1-A	6.33	6.56	5.83	5.58	6.33	6.93
2-A	6.22	5.89	5.25	5.33	6.22	7.17
3-A	6.16	6.26	5.92	5.17	6.00	5.94
4-A	6.83	6.89	6.18	6.36	7.31	7.38
5-A	8.67	9.28	8.33	7.08	8.00	9.28
6-A	13.25	14.63	11.17	10.00	13.83	15.83
1-B	9.22	8.56	9.17	9.17	9.53	9.00
2-B	8.71	8.47	9.42	9.00	9.39	8.83
3-B	8.11	7.39	6.25	5.58	7.83	8.56
4-B	10.56	10.83	11.42	11.25	11.29	10.88
5-B	6.94	7.06	6.25	6.33	6.69	7.00
6-B	14.78	14.89	13.33	13.33	15.71	15.93

Qualitative findings

The statistical results are reinforced by the instructor's report that by the end of the project, the students in the field trip group were utilizing her as a mentor and were more willing to interact with her and listen to her advice than students who were in her other classes. She felt that the students who had the experiences outside of the school environment got to know her better and the shared experience of the field trips was a method of reaching a different level of interaction with her students. She was also of the opinion that the hands-on interaction in the field-like environment provided more stimulation to the students than sitting in a class lab experiencing similar content.

Differences were also noted in the field trip students' responses over time on the SEC post-trip surveys. For example, students responded to the surveys given at the beginning of the project with short single word responses while later survey responses were more elaborate and related to specific field trip experiences. Additionally, during the later field trips, students were overheard discussing earlier field trips.

CONCLUSION

The evidence – both quantitative and qualitative - indicates that field trips increase students' attitude toward and possibly interest in science and provide a useful pedagogical tool that allows more student interaction with positive role models in the various scientific disciplines. It is apparent from these findings that multiple science-related field trips further develop student engagement and help students develop connections from one trip to the next as well as between the concepts they are studying in class and the real world. The changes seen in the students who attended the field trips are not mirrored in either the control group (traditional instruction) or the comparison group (SEC-in class presentation). The results are even more compelling in that the comparison group (SEC-in class presentation) consisted of honors students who are traditionally viewed as excelling in science and presumably have a more positive attitude toward science.

RECOMMENDATIONS

The following recommendations were borne out of the results of this evaluation, a review of the available research, and comments from students and project personnel.

1. ***Assess science knowledge pre and post project*** –It would be beneficial to determine the impact this project has on science knowledge and associated achievement.

2. ***Spread out field trips over a longer period of time*** – Attending six field trips in the span of six weeks was difficult for the field trip students because they missed other classes and had a lot of makeup work. It also forced the

science teacher to compress more of her lessons into long lecture sessions, to make up for the class time that was spent on the field trips. Additionally, lengthening the time between field trips would allow for more in–class pre- and post-trip discussion and activities about each field trip, rather than just jumping into the next one. Further, having more time to impact students' attitudes is likely to have a more positive, longer-term effect.

3. ***Engage students in more hands-on activities (less lecture)*** – Students were more interested, more actively engaged, and seemed to learn more from the hands-on activities than from sections of a field trip that involved passive learning. Implementing this recommendation will also help to distinguish the field trip group even further from the comparison group (SEC-in class). Students also indicated that they preferred to receive instruction during activities, rather than prior to activities. Research indicates that it is ideal to have a limited number of open-ended tasks that require observation, discussion, and deduction rather than a lot of written recording of factual information.

4. ***Ensure age- and skill-appropriate lessons and tasks*** – It is important that the field trip personnel are comfortable working with young adults and adequately prepare their presentations to match the skill level and attention span of adolescents. The most effective presentations were short in length and did not use excessively technical jargon. Students responded well to probing questions asked by the presenter, but care should be taken to ensure that all students are encouraged to answer questions instead of relying on volunteers. Also, splitting the class into small groups during the presentation and lesson activities greatly facilitated student engagement.

5. ***Ensure teacher preparation, communication, and support*** *(especially as the project expands to other teachers and schools)* – While the crux of implementing the SEC Curriculum Enhancement Project rests with the SEC member organizations, a large component not to be overlooked is the influence of the classroom teacher. To optimize the attitudinal and cognitive gains, teachers and other project personnel must provide support and ''scaffolding'' between the students' existing knowledge and the real-life science they are experiencing on field trips (Anderson, Lucas, Ginns,&Dierking, 2000; Bitgood, 1993; Brooke & Solomon, 1996; Koran, Koran, & Ellis, 1989).

Research (Price and Hein, 1991; Osborne, 2003) shows that teacher and student attitudes, discipline, interest, and enthusiasm benefit when the teacher:

- Has a thorough understanding of the topic that will be experienced on the field trip
- Receives pre-program orientation about the field-trip sites
- Has input into the design of the programs

- Is actively involved by institution staff in running the program sessions
- Provides relevant in-class activities and objectives in preparation for the field trip
- Makes it clear to his/her students that the visit is a learning experience, not only a recreational day out.
- Explains the structure of the day and the environment to the students before the visit to reduce any potential anxiety about not knowing what to do.
- Encourages explanatory talk between peers
- Provides relevant in-class follow-up activities after the field trip
- Reviews and recalls the visit and ideas experienced in the science museum later in the academic year when studying related new science topics.

6. Ensure effective engagement of other personnel - Field trip personnel and chaperones also have a potentially important role in influencing students' attitudes. Research shows that helpers are more effective when they are given clear, manageable tasks, including advice on communicating with students in an age-appropriate manner. As Brown (1999) found, successful helpers showed an interest in what the students were doing; gave practical help and encouragement when difficulties arose; gave verbal help, such as reading labels or discussing exhibits with the students; or acted as partners for the students. This places responsibility on the teachers to adequately prepare and advise their helpers (Jarvis and Pell, 2005).

7. Provide resources to reflect the needs of multicultural students – Sarasota County Public Schools is a diverse school district representing students of varied nationalities and ethnic backgrounds. Although this pilot study involved only a small number of students, students were often observed working together and conversing in Spanish amongst themselves and a field trip chaperone. No materials were provided in alternate languages for these students, which resulted in the need for an interpreter. As the project expands, this need will likely become more pervasive.

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APPENDIX A

SEC and Member Organization Field Trip Sites

Science and Environment Council of Sarasota County
1999 Lincoln Dr. St., Suite 202
Sarasota, FL 34236
(941) 955-9089
http://www.secsc.org

April 4, 2007
Lemur Conservation Foundation
(941) 322-8494
http://www.lemurreserve.org

April 11, 2007
Urban Forestry presentation at
Marie Selby Botanical Gardens
811 S. Palm Avenue, Sarasota, FL 34236
(941) 366-5731
http://www.scgov.net/forestry

April 18, 2007
Marie Selby Botanical Gardens
811 S. Palm Avenue, Sarasota, FL 34236
(941) 366-5731
http://www.selby.org

April 25, 2007
Crowley Museum and Nature Center
16405 Myakka Road, Sarasota, FL 34240
(941) 322-1000
http://www.crowleymuseumnaturectr.org

May 2, 2007
Mote Marine Laboratory
1600 Ken Thompson Parkway, Sarasota, FL 34241
(941) 388-4441
http://www.mote.org

May 9, 2007
GWIZ - The Hands-On Science Museum
1001 Blvd. Of the Arts, Sarasota, FL 34236
(941) 309-4949
http://www.gwiz.org

APPENDIX B

The Scientific Attitude Inventory (SAI II)

Gender: Male Female ID: ____________

Age: ___________ Grade: ______________ Class Period: ____

Primary language spoken at home: English Spanish other: ____________

What words come to mind when you think of a scientist?

What areas of science do you like most?

There are some statements about science on the next few pages. Some statements are about the nature of science; some are about how scientists work. Some of these statements describe how you might feel about science. You may agree with some of the statements and you may disagree with others.

After you have carefully read a statement, carefully decide whether or not you agree with it. If you agree, decide whether you agree mildly or strongly. If you disagree, decide whether you disagree mildly or strongly.

Please place a checkmark in the box of the response that best describes what you think about each statement below. Please respond to each statement and mark only one box for each statement.

	Strongly Agree	Mildly Agree	Neutral	Mildly Disagree	Strongly Disagree
1. I would enjoy studying science.					
2. Anything we need to know can be found out through science.					
3. It is useless to listen to a new idea unless everybody agrees with it.					
4. Scientists are always interested in better explanations of things.					
5. If one scientist says an idea is true, all other scientists will believe it.					
6. Only highly trained scientists can understand science.					
7. We can always get answers to our questions by asking a scientist.					
8. Most people are not able to understand science.					
9. Electronics are examples of the really valuable products of science.					
10. Scientists cannot always find the answers to their questions.					
11. When scientists have a good explanation, they do not try to make it better.					
12. Most people can understand science.					
13. The search for scientific knowledge would be boring.					
14. Scientific work would be too hard for me.					
15. Scientists discover laws which tell us exactly what is going on in nature.					

	Strongly Agree	Mildly Agree	Neutral	Mildly Disagree	Strongly Disagree
16. Scientific ideas can be changed.					
17. Scientific questions are answered by observing things.					
18. Good scientists are willing to change their ideas.					
19. Some questions cannot be answered by science.					
20. A scientist must have a good imagination to create new ideas.					
21. Ideas are the important result of science.					
22. I do not want to be a scientist.					
23. People must understand science because it affects their lives.					
24. A major purpose of science is to produce new drugs and save lives.					
25. Scientists must report exactly what they observe.					
26. If a scientist cannot answer a question, another scientist can.					
27. I would like to work with other scientists to solve scientific problems.					
28. Science tries to explain how things happen.					
29. Every citizen should understand science.					
30. I may not make great discoveries, but working in science would be fun.					
31. A major purpose of science is to help people live better.					

	Strongly Agree	Mildly Agree	Neutral	Mildly Disagree	Strongly Disagree
32. Scientists should not criticize each other's work.					
33. The senses are one of the most important tools a scientist has.					
34. Scientists believe that nothing is known to be true for sure.					
35. Scientific laws have been proven beyond all possible doubt.					
36. I would like to be a scientist.					
37. Scientists do not have enough time for their families or for fun.					
38. Scientific work is useful only to scientists.					
39. Scientists have to study too much.					
40. Working in a science laboratory would be fun.					

APPENDIX C

Selected Field Notes

Lemur Conservation Foundation:

- Notice a male student asking one-on-one questions of the presenter to follow-up her presentation.
- When first outside, students are looking around trying to see the lemurs in the distance.
- Students are all working together on the task – all are engaged.
- Students can hear the lemurs making noises and want to see them.
- Students are very interested in the lemurs and their behaviors:
  - Ask about the radio collars that some of them wear around their necks
  - Notice the different noises that are made by different species of lemurs
  - Ask about the names of the different species
  - Observe differences in physical characteristics of different species
  - Observe the electric fence and ask questions about how it works
  - Male student asks, "Will they be released into the wild?"
  - Male student asks, "Why are some animals kept in separate habitats?"
  - Guide describes eating habits, and female student inquires about the specifics, "Why can't [lemur species] eat melons?"
  - Students take pictures of lemurs with their camera phones
- Female student says (during experiment) "I feel like a scientist."
- Multiple female students say "They're so cute!" – LCF staff shows them scar that required 5 stitches!

Sarasota County Urban Forestry Program:

- 3 male students engage guide in conversation about the fruit flies that the class is breeding for upcoming presentation at Selby Gardens next week.
- 4 male students engage guide with questions about nature features they see along the trail.
- Guide saying it's illegal to remove mangrove trees; male student states "It's sad that they take away trees to build houses on the water."
- Demonstration of environmental toxins peaked students' interest.
- Students brainstormed many ideas to reduce their impact on the environment.

Marie Selby Botanical Gardens:

- Group is mostly engaged, a few distracted by aquarium, frogs, fruit flies, etc.
- All students at a table harvest flies into one container per table – all students are engaged in activity.

- Female student says: "It's cool when they [the frogs] stick out their tongue."
- When finished, 1 male student and 1 female student help put their frog back in the tank & add extra flies to tank for frog to eat.
- Male student demonstrates pruning technique to female student next to him when she looks confused.
- On way to research facilities, 2 male students from another group stopped to show classmates what they had just made – pickled plants.
- 1 female student asked a lot of questions and seemed fascinated. She wanted to know about jobs in Ethnobotany.
- Students liked looking at seeds in different stages of growth.
- 1 female student invited chaperone to come look through the microscope.
- 1 male student liked trying to draw magnified image and stayed with it for a while.
- 1 female student was disappointed when she had to give up her microscope to another student, but then happily assisted.
- 1 female student couldn't stop talking about the lemurs from the field trip 2 weeks ago.
- Students didn't want to stop working on their sticks (epiphyte logs).
- Students were excited to take logs home to grow.
- Students work together and help each other with constructing logs.
- Students show teacher their logs when done.

<u>Crowley Museum & Nature Center:</u>

- Overhear male student talking about his epiphyte log from last week's trip
- Female student shows male student how to work light meter; instructs him on how/where to get the best reading.
- Students identify a plant they saw at Selby Gardens.
- Overhear female student asking guide about careers and names of different types of scientists. Guide answers her questions; student tells guide about things she is interested in.
- As the trip progressed, students were more comfortable with identifications and instrument readings.
- Students asked guide to identify plants, animals (mostly birds) and sounds.
- Students described things they were seeing to each other.
- All groups were engaged in the wrap-up session
- Spokesperson for each group presented their findings to the whole class and answered questions about biodiversity and different habitats.

<u>Mote Marine Laboratory</u>:

- Students talked about marine animals while walking to the first session.
- Students asked about dolphin behaviors that they saw; asked what's wrong with the dolphins in the nearby critical care unit.
- All students were interested in watching the dolphins while waiting for the training session to begin.
- Male student asked about volunteer program; how old do you have to be?

- Students asked a lot of questions during the dolphin training session.
- Male student asked how to become a dolphin trainer.
- Male student asked about manatee tracking device on display.
- Male student asked "What's that white spot on that one [manatee]?" – removed abscess.
- Male student asked how big turtles get.
- On walk through aquarium, male student points out sharks in the tanks to teacher and friends.
- When asked how many of them want to work with animals, more than half of the students raised their hands.
- 2 male students talked about the "power" lab they did in class.

Gulfcoast Wonder & Imagination Zone (G.WIZ):

- All students enjoyed the human circuit activity.
- Students convinced teacher to participate in Vandegraff machine demonstration; students take pictures with camera phones of teacher with hair standing up.
- During direct current activity, students worked together with different type of connections to illuminate light bulbs.
- A male student expressed interest in making a speaker with household objects.
- All students interacted with museum exhibits.
- “Mindball” game was very popular.
- Students gravitated toward interactive exhibits in museum.