A MIXED METHODS EVALUATION OF AN AFTERSCHOOL SCIENCE CLUB'S INFLUENCE ON ADOLESCENT GIRLS' ATTITUDES TOWARD SCIENCE

A Dissertation

Presented to the Faculty of the Graduate School

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

by

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August 2006

A MIXED METHODS EVALUATION OF AN AFTERSCHOOL SCIENCE CLUB'S INFLUENCE ON ADOLESCENT GIRLS' ATTITUDES TOWARD SCIENCE

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Cornell University 2006

Attitudes toward science have an impact on how and what students learn, which directly influences student achievement and student self perceptions. Attitudes have been shown to affect achievement scores and student self-concept. This study explores student attitudes toward science in grades seven and eight. Attitudes toward science, which are defined as positive or negative feelings about science, were measured at three different times during the school year for all students in grades seven and eight. A girls' science club intervention program was implemented for those in grades seven and eight who self-selected to participate. A mixed methods approach was used to collect both quantitative and qualitative data concerning attitudes over time for girls participating in the intervention program. Quantitative data was collected for students not participating in the club to provide data comparative data. Quantitative results indicated differences in attitudes over time for all students when data was pooled across grade levels. Additionally, grade level differences over time were observed in grades seven and eight, with grade seven showing an increase in scores over time and eighth graders showing a decrease in scores over time. No significant effects of gender were found, although there was a gender trend observed over time.

In the qualitative data, similar categories emerged over time in response to survey and interview questions. There were no major differences observed in survey responses from the beginning to the end of the year. Qualitative data in some cases provided corroborating information in support of quantitative conclusions. In other cases, the qualitative data hinted at different conclusions.

This study found that the science club intervention program did not have a positive effect on girls' attitudes toward science. Factors beyond the intervention including the school environment and achievement expectations appeared to have more of an influence on attitudes than the intervention program. Further study is needed to determine if this phenomenon would occur in future cohorts of students and also to continue to evaluate the effectiveness of science programs in both formal and informal settings.

BIOGRAPHICAL SKETCH

Anna M. Waldron received her B.A. in English Education from Ithaca College in 1993 and her Master of Library Science degree from Syracuse University in 2000. Ms. Waldron has developed science education programs for six years, including science clubs for girls, high school and college research experiences, and teacher professional development programs. Her research interests include how young people, particularly women, approach science and how people come to understand nanotechnology.

This dissertation is dedicated to my husband, Matthew Waldron, who has supported my scholarly endeavors over the past six years. Without his support, I would never have started down this path, which is now completed.

ACKNOWLEDGMENTS

I would like to acknowledge the guidance of my mentor, William M. Trochim, over the past six years as I have explored program evaluation, statistical analysis, and other areas related to my research. I would also like to acknowledge the dedication of my special committee members, Dawn E. Schrader and Bruce V. Lewenstein, for their support in helping me articulate my educational ideas and theories. Finally, I would like to acknowledge the National Science Foundation, which has supported this work through my appointment as Director of Education at the Nanobiotechnology Center.

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TOSRA (Test of Science Related Attitudes)

CHAPTER 1

INTRODUCTION

1.1 Importance of the Study

What motivates adolescents to do or not do something? What leads them to be interested in some things and completely disinterested in other things? There are so many factors at home and at school that affect how adolescents perceive the world around them. Each factor influences how they learn, what they learn, why they learn, everything about learning. Does anything in our educational system help open their eyes to learning about things they never considered? After all, that is what enrichment in any form is meant to do. To enrich the experience of the students so that they can have a broader experience base from which to work once they begin to function independently. One of our goals as educators is to help students expand their possibilities, to raise awareness of things not previously known to them, to provide experiences that will help them see a bigger world and decide for themselves what path to pursue.

How can we get inside the teenage girl's mind to figure out what influences her attitudes toward learning? If we find these answers, can we build upon that knowledge to help girls grow, develop and learn? Can we use these answers to help girls through the difficult transitions into adolescence and adulthood? As researchers, we can study a group of girls to see if any patterns emerge in the way they interact with the world. We can design learning experiences that will help girls transition from children into adults who can think independently and make good life choices for themselves.

The science club intervention program detailed in this study grew out of the belief that one enrichment program *can* make a difference in girls' lives. No matter how small or big the effort, anything we do as educators has the potential to influence the students in some way. How can we maximize that influence while also keeping the learning environment open so that we are not indoctrinating the students but rather helping them explore new areas? The science club is just one example of a program that was developed to offer new opportunities to a small group of girls who participated in and were changed by the experience. The experience could cause significant change or change that is so small, it is imperceptible. It could also cause change that is not manifest until many months or years after the experience. As a personal recollection, I remember going birdwatching with my aunt and uncle many times as a child, and now I am an avid birdwatcher. Who knew that those weekend jaunts in the little green Honda would help me develop into a lifetime bird lover?

As adults and mentors, we have no idea what our connection with kids will bring. We have goals, we have hopes, but in the end it is up to each individual to take that experience and blend it into his or her broader experience. With the science club intervention program, we can look to see if there was an effect of the intervention on girls' attitudes toward science. We hope that the club will make a difference in the girls' growth and development. However, that difference may not appear for years to come, it may never make itself known, or it may never happen. As educators, we feel we have made a difference, and yet it is difficult to measure this difference. In addition, the school environment with its achievement and social expectations act as noise for the differences that a simple intervention program could make. This study looks at one intervention program with a specific goal of increasing or maintaining girls' positive attitudes toward science as they transition through middle school.

1.2 Context of the Study

Attitudes toward science among girls evolve over time, and there is typically a decline in attitudes during the middle school years. This decline influences achievement and self-concept in adolescent girls. Many factors such as teachers, parents, media, and friends impact girls' attitudes toward science. For each individual, some factors influence attitudes more than others. The interactions between these things can shape individual attitudes in different ways. To frame the context for the current study, we will look at factors that influence attitudes toward science and begin to discover what causes this attitudinal change. We will look at how attitudes are defined and how, then, attitudes toward science are defined (see Chapter 2). Using these definitions as guides, we should begin to understand the relationship between attitudes and learning. We will consider factors that influence attitudes, factors that influence learning, and the interplay between these factors. Some of the factors influencing science learning include teachers, parents, friends, and the school environment. We will offer definitions of attitudes toward science based on these factors that will capture the essence of girls' attitudes toward science during their adolescent years. Using this understanding to inform our study, we will evaluate attitudes toward science and begin to uncover what factors are most critical in causing attitudinal changes over time in teenage girls.

The complex notion of how students learn, and how girls in particular learn, will be explored to help us understand how gender shapes learning (see Chapter 3). The social construction of knowledge that occurs within girls is influenced by context, experience, and self. The role of these three factors in girls learning will be explored to help us uncover what is going on in girls' development that impacts their attitudes toward science. Knowing how girls learn will help us understand their perspectives on learning and will inform the interventions that we use to help encourage their learning. In this study, we look specifically at science, but the theories of how girls learn could be applied to any subject area. Girls' needs and perspectives should be taken into account when creating educational programs that will foster their development as they move from young girls into adolescence.

1.3 The Study

The heart of this study explores the differences in girls' attitudes toward science over time. If we determine what factors influence positive and negative attitudes toward science, then perhaps we can help to reverse the trend of students losing interest in science during the middle school years. In this study, attitudes are studied during the course of a school year and also for two different grade levels of girls. As a comparison, attitudes of boys are also studied to explore differences that may occur between genders at a particular age.

The study took place in a rural school district in Central New York. The town population was 5,800, and the school building combined middle and high school for grades seven through twelve. The school population for grades seven through twelve was 495 students, with grade seven having 89 students and grade eight having 91 students. Two teachers were responsible for science instruction for all seventh and eighth graders, with one dedicated to grade seven, Life Science and one teaching grade eight, Physical Science.

Two research questions framed the study (see Chapter 4): “Do attitudes toward science change during the course of the school year in grades 7 and 8?” Based on previous research, it was hypothesized that attitudes toward science among students in grades seven and eight would decrease during the course of the school year. The second research question was, “Does a science club for girls influence girls’ attitudes toward science in grades 7 and 8, and is there a difference in attitude change between grades 7 and 8?” Three hypotheses formed the basis for data collection related to this question. The first hypothesis was, “Girls who self-select to participate in the science club for girls will have higher attitudes toward science at beginning, middle, and end of the year than girls who choose not to participate.” The second hypothesis also related to the intervention: “Intervention in the form of a hands-on science club will maintain or increase girls’ positive attitudes toward science.” The third hypothesis studied grade level differences: “For all participants studied, there will be a greater change in attitude at grade 7 than at grade 8.”

By framing the study within these research questions, we are able to look at attitude changes over time for students in grades 7 and 8. We will explore the individual results of the study by instrument: TOSRA, surveys and interviews (see Chapter 5). We will then synthesize the results by instrument to see if there are grade level, intervention, and gender differences over time (see Chapter 6), and we will discuss each research question and its related hypotheses in the context of the theories that frame the study. Finally, we will speculate about implications of the study and its results as well as considerations for future research that will enlighten the study of attitudes toward science during the middle school years (see Chapter 7).

1.4 What the Study Tells Us

What we discovered through this study was that the design of the study, a quasi-experimental design with mixed methods, allowed us to make conclusions about girls' attitudes toward science that would not have been possible without the methodology used. The mixed methods approach to the study allowed for a combination of solid quantitative data with rich qualitative data. The quantitative portion of the study gave definitive results about attitudinal changes over time, while the qualitative portion provided insight into what was causing changes in girls' attitudes. The qualitative data told us things that would not have been apparent with the quantitative data alone.

If we step back and look only at the quantitative results of the study, we surmise that the science club for girls had no positive impact on attitudes toward science over time. The statistical results clearly show that there were no significant differences over time for girls who were involved in the science club versus those who were not. Attitudes toward science appear to be statistically unrelated to their involvement in the intervention program. We conclude that science clubs are not effective in helping improve girls' attitudes toward science during the middle school years.

If we put aside the quantitative data and look exclusively at the interviews and surveys, we find that girls are very much influenced by their teachers and the overall school environment during grades seven and eight. We find that they joined the club to learn more about science and that they liked doing experiments and attending field trips where they were able to explore scientific concepts. In this qualitative data, we also find that girls like communicating with each other and with scientists and that their appreciation for scientists grows over time. Overall, we conclude that the science club had a positive impact on the girls' attitudes as evidenced through their survey and interview responses.

Clearly, the outcomes of these two types of analyses based in two different kinds of data collection are exactly opposite. With the quantitative analysis, the intervention is a failure at improving attitudes over time. Conversely, in the qualitative analysis, the intervention is a stellar success. The girls in the club really liked science and scientists, and their appreciation for scientists deepened over time. The number of girls in the club also increased over time, showing that the intervention was successful not only at improving girls' attitudes but in attracting additional girls as the year progressed.

The value of the mixed methods approach to this study is that it allows us to take two different kinds of data with two different types of analysis and combine the results into a coherent picture that tells us so much more than the sum of the two parts. The quantitative results show that attitudes change over time, but that these attitudes must be impacted by factors beyond the scope of the intervention. And when we dig into the qualitative information gleaned through interviews and surveys, we begin to uncover factors that were impacting the girls over time that were much bigger and more influential than the intervention program itself. We can blend the results from these two different kinds of analyses to form a better picture of what was really going on during the school year for the girls. We can then speculate about the big picture factors in the girls' environment, both at school and beyond school, that influence how they interact with science and with other content areas. We will explore these ideas in Chapter 7.

This study also illustrates the difficulties facing researchers who evaluate science education programs. The effects of one intervention are potentially lost within the context of the greater experience of those under study. It is difficult to measure the change within individuals and within populations because of all the other variables that impact the individuals and the interactions between individuals. Given the effect of factors outside the scope of the study, it is difficult to discern what causes change over time in the population being studied. Within the current study, it was difficult to determine what caused major shifts in science attitudinal scores over time. We can speculate and draw conclusions based on the various quantitative and qualitative data sources, but in the end we cannot rule out alternative explanations since the list of possible alternative explanations is expansive.

CHAPTER 2

LITERATURE REVIEW: ATTITUDES TOWARD SCIENCE

2.1 Definitions of Attitudes Toward Science

Attitudinal research involving adolescents is based in two fields: educational psychology and cognitive psychology. Educational and cognitive psychologists study attitudes in terms of motivation and achievement. Pintrich and Schrauben (1992) outline a social cognitive model of student motivation that provides a framework for the proposed study. Within this model, attitude is embedded in the construct of motivation. In their model (p. 153, see below), students with positive motivational beliefs tend to have increased engagement in tasks and tend to use cognitive strategies effectively to attain high achievement (p. 172). Within this model, motivation has three components: expectancy, value, and affect. Expectancy includes “individuals’ beliefs about their ability to perform a task, their judgments of self-efficacy and control, and their expectancy for success at the task” (p. 154). Value is the component in which we find attitude, which is considered a process aspect of a task. “Student interest in the task is a more process and less instrumental aspect of task value. Interest is assumed to be individuals’ general attitude or liking of the task” (p. 158). Affect includes student “emotional reaction to the task and their performance…and their more emotional needs in terms of self-worth or self-esteem” (p. 152). Motivation, then, is a key component in determining student involvement in learning and in predicting academic achievement. Situated within the construct of motivation is attitude.

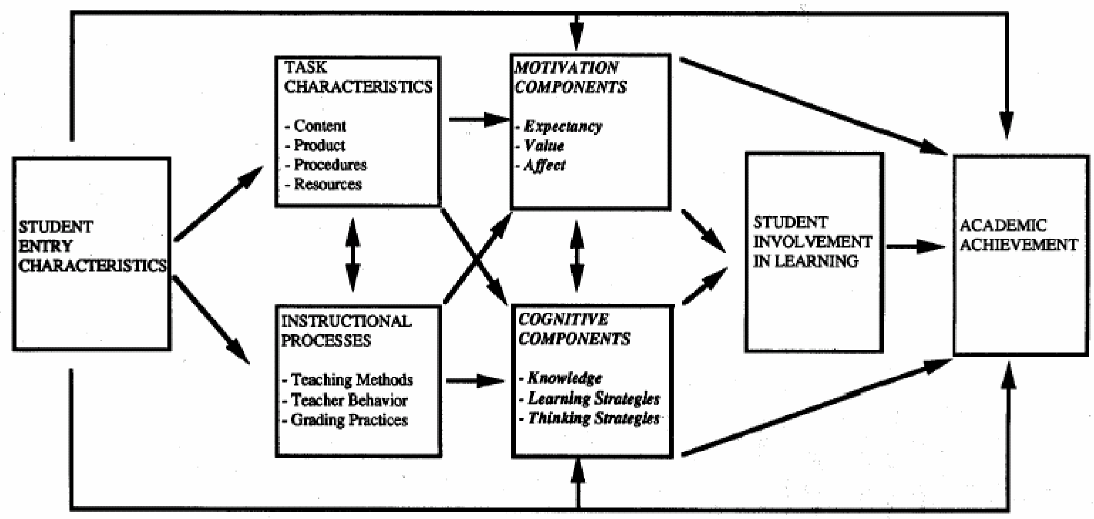

FIG. 7.1 Conceptual framework for motivation and cognition in the classroom context.

Figure 2.1 Conceptual framework for motivation and cognition in the classroom context, from Pintrich and Schrauben, 1992

Much research has been published on the topic of middle school girls' attitudes toward science within the context of achievement. For example, how do attitudes toward science affect achievement on standardized tests? (White and Richardson, 1993). Less attention has been paid to how attitude influences interest in science or in a scientific career as young women move from middle school to high school and beyond. Several studies focus on why young women choose not to pursue science in college (NSF, 1994) but little has been published on interventions at the middle school level that can encourage young women to pursue science as they progress through school. According to Handley and Morse (1984), "Little attention, however, has been given to investigations in the areas of natural science, particularly as related to the junior high age group, the critical era during which girls appear to make decisions to self-select themselves out of advanced courses in science" (p. 599).

Evidence of girls losing interest in science is found in attitudinal studies such as the NCES study from 1999. The NCES reported differences in attitudes between males and females based on data collected in the 1996 NAEP science assessment (O'Sullivan and Weiss, 1999). At the eighth grade level, fewer females than males liked science (47% vs. 54%). Fewer females also felt they were good at science (42% vs. 52%). At grade 12, the trend remained the same, with fewer females than males liking science (48% vs. 56%) and feeling they were good at it (33% vs. 45%). Even more disturbing is that at the twelfth grade level, 36% of females said they would not study more science if they had a choice, compared with 30% of males. Based on this report, we see that girls' attitudes toward science are more negative than the attitudes of their male peers and this is progressive with time. Intervention in the early teens may improve girls' attitudes toward science as they move through middle school and into high school.

After school activities can be effectively used to promote gender equity in the sciences, according to the U.S. Department of Education's Gender Equity Expert Panel (Rousso and Wiberg, 2001). In a report published in August 2001, two of five exemplary programs featured were after school science programs designed to promote gender equity. One program, the National Science Partnership for Girl Scouts and Science Museums, partnered science museums with girl scout clubs to promote science to girls ages 6 to 11. Another program, Family Tools and Technology, targeted girls and boys with a goal of increasing the number of girls interested in science and technology and maintaining their interest. This program provided career role models and allowed parents and girls to participate in activities that would typically be provided to boys.

To begin to study how attitudes toward science change at the middle school level, we first must define attitudes toward science. From an educational psychology perspective, attitudes are "internal states that influence personal action choices" (Good and Brophy, 1990). Shrigley (1983) reviewed the term attitude as defined by several key social scientists from the early 1900s to the present. He began with an explanation of how attitude is influenced by knowledge. "If attitudes are learned, then information acquisition must be central to attitude change" (p. 427). Acquisition of knowledge shapes individual attitudes toward a particular subject or object, in this case science. Shrigley credited Bogardus in the 1920s with the idea of measuring attitude quantitatively and highlighted Thurstone's work in which attitudes were measured on a scale from highly favorable to highly unfavorable. Shrigley also presented Hovland's persuasive communication approach, which was the basis of attitude research from the 1930s to the 1960s. "Often referred to as the learning theory approach, they assumed that humankind is rational and that we should confront subjects with formal, oral, or written communications expecting them to learn attitudes much as they learn life's basic skills" (p. 428). Although each researcher focuses on a different aspect of attitude, they converge upon the idea that attitude is shaped by the learning environment. We will see this idea reinforced in the when we explore the social construction of knowledge and the role of experience in that process in Chapter 3.

In concluding his review of attitudinal research, Shrigley posed the following statements about attitude: 1) Attitudes are learned; cognition is involved; 2) Attitudes predict behavior; 3) The social influences of others affect attitudes; 4) Attitudes are a readiness to respond; and 5) Attitudes are evaluative; emotion is involved. These conclusions inform the study of attitudes toward science and are applied in numerous studies with students at the middle school level.

Simpson and Troost (1982) defined attitude as commitment to science. Attitude includes "the interests, attitude, values, and other affective behaviors of students…" (p. 765). These attitudes include student interest in science majors and student desire to take science courses, read scientific articles, explore scientific topics, and be involved in social issues related to science. Simpson and Troost studied attitude as evidenced in behaviors such as reading, exploring and getting involved in science.

There is an important distinction between scientific attitudes and attitudes toward science, as noted by White and Richardson (1993). In 1985, Koballa and Crawley defined attitude toward science as "a general and enduring positive or negative feeling about science. It should not be confused with scientific attitude, which may be aptly labeled scientific attributes (e.g. suspended judgment and critical thinking)" (Koballa and Crawley, 1985, p. 223). Scientific attitude has more to do with how one approaches a scientific problem, whereas attitude toward science involves feelings toward or against science. In 1988, Koballa described attitudes toward science as learned predispositions to respond in a consistently favorable or unfavorable manner toward science. Koballa provided three reasons for studying attitudes toward science. Attitudes are relatively stable over time. Attitudes are learned as students experience the world around them. Attitudes are related to behavior in that people will act according to their feelings toward or against something.

These various definitions of attitude toward science have a few characteristics in common. First, attitudes are evidenced in behaviors toward or against objects.

Science is the object, and attitudes can be quantitatively and qualitatively measured for or against it. Attitudes are based in feelings toward or against objects, so there is a subjective nature to this line of research. Subjects feel in certain ways about objects, and these feelings change over time. In the area of attitudes toward science, positive feelings toward science have been shown to decrease over time as students transition from elementary to secondary school (Cannon and Simpson, 1985, Simpson and Oliver, 1990).

2.2 Studies of Attitudes Toward Science

Simpson and Troost (1982) undertook a ten-year longitudinal study of 4500 students "…to examine commitment to science and achievement in science among adolescent students in light of important individual, family, and school influences" (p. 764). They hypothesized that self-related, school and classroom, and familial variables would have an effect on science affect and science achievement. Due to the large size of the study, several individual hypotheses were created and studied individually over a several year period. For example, Simpson and Troost hypothesized that friends' attitudes toward science would have an impact on both science affect and achievement. They also hypothesized that gender would have an impact on these two outcome variables (p. 776). Data supporting these hypotheses were published subsequently by various authors including Simpson and Troost, as seen below.

Cannon and Simpson (1985) measured attitude toward science at the beginning, middle, and end of the school year among 4500 students using data collected by Simpson and Troost (1982). "Science attitude at the beginning of the school year was more positive than at the end of the year across both gender and ability groups. The main effect, gender, was not found to be significant" (Cannon and Simpson, 1985, p.

127). Although gender was not significant in this study, Cannon and Simpson noted that male attitudes were consistently higher than female attitudes. They concluded:

> Findings from this study suggest that there are significant difference in science attitude and achievement by gender. Males had more positive attitudes toward science and achieved higher in science than females even though females were more motivated than males to achieve in science. These attitudes and behaviors may be due to gender role stereotyping in our society. (p.135)

Both female and male attitudes toward science are shaped by their environments, as noted by Fishbein (1975). Interventions to the environment may help positively influence these attitudes.

Talton and Simpson (1986) examined the relationships of self, family, and classroom environment with student attitude toward science using data from the ten-year longitudinal study conducted by Simpson and Troost. They found that "family, self, and classroom play an important role in student attitude toward science" (Talton and Simpson, 1986, p. 373). Classroom environment had the strongest relationship with attitude toward science, a fact that is significant when undertaking studies within the school environment such as the study at hand.

Oliver and Simpson (1988) used the ten-year study data to track achievement among high school students in an attempt to answer the question, "…does attitude toward science, achievement motivation, and science self concept predict achievement in science?" (p. 145). One variable studied was attitude toward science as measured by the question, "To what extent does a student have interest in science?" (p. 144). Results of the study did not find that attitude directly influenced achievement. "Although attitude toward science was not usually a powerful predictor of achievement in multiple regression examples, achievement motivation and science self concept were" (p. 153). Motivation to succeed in science and high self-esteem in science impacted achievement, but the question of student attitude toward science for its own merit was not studied.

In 1990, Simpson and Oliver published a follow-up of the previous study. Significant conclusions were made regarding attitude toward science. First, within the population studied, attitude toward science dropped each year.

> Within this large population of students from grades 6-10, attitude toward science dropped each year. The greatest drop always occurred from beginning to middle of year. There was also a steady decline across grades, from sixth through tenth, with an overall attitude at the end of the tenth grade being near neutral. Attitude toward science was consistently higher among boys. (p. 12)

Most notable about this finding is the drop between the beginning and middle of the year. Previous studies had not surveyed at the middle of the year. This significant drop in attitude in all four grade levels may indicate some factor within the classroom that has degenerative effects on attitude.

Another important finding by Simpson and Oliver (1990) was related to influence of peers on attitudes toward science. "Adolescents' attitudes toward science are highly positively correlated with their friends' attitudes toward science. This relationship peaks in the ninth grade" (p. 13). Friends' attitudes toward science are an important factor in determining students' continued interest in science. As noted,

> Students likely become influenced by group norms, accelerating either an upward or downward spiral of attitudes toward science. This is supported by the theory of reasoned action (Fishbein, 1975) which suggests that behavior is

> primarily influenced by a combination of the individual's attitude toward the behavior and the attitude of his or her peers toward the behavior. (p. 7)

The combined negative attitudes of students will obviously have a greater impact on the culture of a classroom. A possible negative side effect from this phenomenon is that students with a positive attitude could move into a negative position due to peer pressure or a decline in overall classroom attitudes toward science. A third finding of this study involved students' self-concept at the tenth grade level. As self-concept and attitudes decline into the tenth grade year, students elect to take fewer science courses. These decisions can significantly alter career paths as students move through high school and on to college or post-secondary careers.

> Science self-concept at the tenth grade level is a good predictor of both number and type of science courses a student will take during high school. In particular, students with lower attitudes do not appear to pursue additional courses in science. A major finding of this study, therefore, is that attitudes toward science play a key role in influencing the amount of exposure to science a student experiences. (Simpson and Oliver, 1990, p. 13)

To gain acceptance into many colleges and universities, students are required to have significant exposure to science and math at the high school level. If students do not choose rigorous course work in the sciences while in high school, their options for scientific career paths may be limited even before they reach college age.

The notion of self-concept, as mentioned above, is prevalent within attitudinal research. Handley and Morse (1984) studied adolescents' self-concept and gender role identification in relation to attitudes and achievement in science. They studied 155 seventh and eighth graders and concluded, "both attitudes and achievement in science are related to the variables of self-concept and gender role perceptions of male and female adolescents" (p. 606). In other words, students' self-concepts and perceptions of their role in society influence attitudes toward science and achievement in science. Within the Handley and Morse study, the relationship between attitudes toward science and the self/gender role changed more than the relationship between achievement and science and the self/gender role. There were no significant differences observed between genders.

Baker examined the factors of attitude toward science, spatial ability, mathematical ability, and the scientific personality, in a sample of ninety-eight eighth grade students (Baker, 1985). Focusing on attitude toward science, his study found that females had a more positive attitude toward science than males. He also found that students with higher grades in science typically had a more negative attitude toward science and conversely, students with lower grades in science had a more positive attitude toward science. This finding is in disagreement with Oliver and Simpson (1988), who found positive correlations between student attitude and student achievement. This disagreement could be due to differences in study design, including sample size (98 subjects versus 4500 subjects) and time period (1 year versus 10 years).

A study specifically aimed at attitudes toward science in the context of careers was undertaken by Bazler (Bazler, et al, 1993). Bazler studied the effects of an intervention program for grades 4-12 on attitudes toward science. The intervention was a five-year program of undersea exploration that utilized telecommunications technology to provide live telecasts from remote sites, enabling students to participate in scientific discovery with scientists. A sample taken of 706 students post-intervention showed an unexpected relationship between grade in school and effect of the experience.

> The Jason Project data revealed a curvelinear relationship between the student's grade in school and the effect of the Jason experience (i.e. middle grades showed more gains). This unexpected finding may suggest that middle schools are the more appropriate grade target for interventions to increase science interests (e.g., elementary grades are too early, and high school is too late to affect interests). (p. 109)

Findings of the Bazler study can be applied generally to science intervention programs, which should occur at the middle school level if they are to be effective in increasing science interests. For the present study, middle school is the target age for the science club intervention since we expect the intervention to have a greater effect with this age than it would if it happened in elementary or high school.

Haladyna and Shaughnessy (1982) reviewed 49 studies of attitudes toward science through meta-analysis in an attempt to quantitatively integrate the results. They looked at attitudes toward science as defined by researchers and then proposed a theoretical framework for the study of attitudes. In concluding their review, Haladyna and Shaughnessy found that "…research on attitudes is diffuse in focus as well as emphasis" (p. 557). They continued, "There has been limited progress in understanding the determinants of science attitudes through previous research. Programmatic research is needed which operates in the context of a conceptual framework and provides findings that are translatable to practitioners in terms of improving instruction" (p. 559). Twenty years later, the efforts to study attitudes toward science are still diffuse. Females are losing interest in science at the middle school level, and many different methodologies are used to investigate this phenomenon. Numerous study designs and instruments have been developed and much research has been published, but we cannot conclude that any one factor predicts girls' sustained interest in science. Therein lies the importance of the current study.

2.3 Conclusion

The present study builds upon the above referenced work to provide a snapshot of attitudes toward science among students in middle school. Attitudes toward science within this study are defined as “a general and enduring positive or negative feeling about science” (Koballa and Crawley, 1985, p. 223). After reviewing this related research that has measured attitudes toward science, the present study uses a mixed methods approach to observe middle school students’ attitudes toward science during the course of a school year. It is expected that this study, like those above, will produce results that show decreases in attitudes over time for students in grades seven and eight. It is also anticipated that many factors including parents, friends, and school will impact student attitudes.

CHAPTER 3

LITERATURE REVIEW: HOW WE LEARN

3.1 Introduction

Educational researchers for the past century and beyond have struggled with the notion of learning and the role of nature versus nurture in the learning process. Behaviorists suggest that learning is the product of a stimulus/response interface, wherein the learner has a relatively inactive role as receiver of knowledge and developer of pre-set skills (Bloom, 1956; Gagne, 1965). Maturationists believe that as we grow physically, so do we grow mentally (Erickson, 1993). As we progress through various stages of physical development, our cognitive processes develop in line with these physical changes. Constructivists posit that all learning evolves from the interaction between people and that cognition is based in the individual yet developed through a social experience (Vygotsky, 1978; Gardner, 1993; Bruner, 1996; Piaget, 2001). This latter view is the focus of the current study, wherein we will look at the nature of learning through a constructivist lens. We will explore the theories of social construction of knowledge and the roles of context, experience, and self in the learning process.

The goal of this chapter is to give a broad view of the social construction of knowledge while positioning the exploration in a specific context. The context in which we are interested is how girls learn and, more specifically, how they learn science. Studies have shown that girls' attitudes toward science affect how they learn science (Simpson and Troost, 1982; Schreiber, 1984; Baker, 1985; Simpson and Oliver, 1985; Talton and Simpson, 1986; Simpson and Oliver, 1990; Clewell et al., 1992). It has also been shown that intervention programs can help girls learn science by fostering positive attitudes toward science (Clewell et al., 1992; Bazler et al., 1993; NSF, 1994). To begin, then, we will step outside of this specific context and look broadly at how we construct knowledge.

3.2 How We Learn

The question of how we learn what we learn is expansive, and for the purpose of narrowing down the topic, we will look specifically at the social construction of knowledge. In the eyes of many researchers (Dewey, 1933; Vygotsky, 1978; Kagan, 1984; Rogoff and Gardner, 1984, 1999; Talton and Simpson, 1986; Rogoff, 1995; Wertsch et al., 1995; Kuhn, 1996; Rogoff, 2003; Fosnot, 2005), we arrive at knowledge through some sort of shared social experience. In some cases, the experience is a transmission/absorption model, wherein the learner absorbs knowledge from a more expert individual or group. In other examples, the participants collectively arrive at knowledge through their social interactions with one another and with the larger society (Dewey, 1933; Vygotsky, 1978; Kagan, 1984; Rogoff and Gardner, 1984, 1999; Rogoff, 1995; Wertsch, 1995; Kuhn, 1996; Rogoff, 2003; Fosnot, 2005). In the latter view, there is not a specific piece of knowledge transmitted, but rather knowledge is created through interaction within the community.

Within these sociocultural theories of learning, there are three areas that influence learning: context, experience, and self. Each of these is intertwined with the others, and it is difficult to separate them into distinct entities because of the nature of the interaction between them. They are recursively related, each being a critical part of the other and playing a key role in shaping the others. These three areas interact dynamically with each other in contributing to the growth of the individual engaged in a learning activity of some kind. Learning activities, too, are dynamic and depending on the nature of the activity one area or another may be more influential in shaping that activity. Learning is a situated activity wherein the individual interacts with an experience, with others, with a topic, and with many other variables. These interactions shape the learning that occurs.

The role of context, experience, and self take on particular meanings depending on the nature of the phenomenon investigated. Context as defined here encompasses the learning situation, social environment, cultural norms and other factors that influence learning. Experience includes both the individual and collective experiences of a person or group as related to learning. Self is the individual perspective in the learning process and is partly defined by age, gender, socioeconomic status, and many other socially constructed factors both inside and outside an individual's control. Now that we have some working definitions to guide our discussion, we will first turn to exploration of the role of context in learning.

3.2.1 Role of Social Context

The context in which learning occurs shapes the process itself. We are part of a socially constructed society, and as such we are influenced daily and over the course of a lifetime by the norms, expectations, and opportunities within that society. What we learn, how we learn, when we learn, why we learn, everything about learning is shaped by the context in which it occurs. Context includes both the immediate environment and the socially constructed society in which a particular learning event occurs.

Learning is influenced by social context (Vygotsky, 1978; Kagan, 1984; Rogoff and Gardner, 1984, 1999; Rogoff, 1995; Wertsch et al., 1995; Rogoff, 2003; Fosnot, 2005). Vygotsky (1978) was the first psychologist to relate culture to how we become who we are. His theories differed from those of his contemporaries for many reasons, including his description of the importance of societal context in learning. Behaviorists at the time were focused on the similarities between animal and human behavior and ignored the social processes of thought, language, and volitional behavior that were the primary interest of Vygotsky. Vygotsky believed that "sign systems" including language, writing, and number systems contribute to behavioral changes in people and in society. He studied the use of sign systems by children as they progressed from one developmental stage to the next. Communication via sign systems was of utmost importance to Vygotsky as he explained the connection between society and learning. "Although practical intelligence and sign use can operate independently of each other in young children, the dialectical unity of these systems in the human adult is the very essence of complex human behavior" (p. 24). Our behavior and our learning are shaped by our communication with one another within the social context (Beaton, 1996). Within the science club intervention program, communication is a critical part of the social context in that girls are able to communicate with each other and with supportive adult mentors including female scientists.

Communication with one another is critical for culturally shared understandings to emerge. We each contribute to culturally shared understandings through talking, writing, and other culturally formed practices. Not within the scope of this investigation, but interesting to consider, is the role of unspoken messages through body language and other silent techniques, all of which contribute to our shared understandings. Specifically within the literature under study is the role of speech and dialogue in communicating to form culturally shared understandings. The role of speech in children's development is critical, and even young children use speech to label things. As they become more sophisticated, they begin to synthesize through speech (Vygotsky, 1978). When young children approach a task, they use speech and thought and action together to accomplish the task. "Direct manipulation is replaced by a complex psychological process through which inner motivation and intentions, postponed in time, stimulate their own development and realization" (Vygotsky 1978, p. 26). Building on the work of Vygotsky, Fosnot asserts that verbal communication between children and adults facilitates the child's development. The child uses language to negotiate meaning (Fosnot, 2005). However, through this constructivist lens, learning is a process that is negotiated within a community. This differs from Vygotsky's view that scientific concepts (i.e., knowledge) can be passed in a top-down way from adults to children. In constructivism, cultural knowledge can only be "taken-as-shared" within a community of knowers (Fosnot, 2005, p. 28). In constructivist theory, knowledge is not an object that can be passed along from person to person.

Rogoff embraces the idea of knowledge being passed from experts to novices. The role of a teacher or other adult is to "lead the learner toward an understanding of the new information" (Rogoff and Gardner, 1984, 1999). The role of the adult (or expert) is to guide the child from the known into the unknown. This is a top-down, extrinsically based approach to the social context of learning, and it is shared by others (Dewey, 1933; Vygotsky, 1978; Greenfield, 1999). Instruction in these settings is used to describe an expert teaching a novice: "…the term instruction seems to be used primarily to refer to situations in which an expert deliberately and explicitly attempts to increase the knowledge and skills of a novice" (Rogoff and Gardner, 1984, 1999, p. 105). Instruction occurs in the interaction between the novice and expert. It can be thought of as a Venn diagram, with the overlapping portion symbolizing instruction. Within this learning exchange, responsibility for learning is transferred from the adult to the novice. In the science club intervention, the adults including the teachers and the scientific role models were the experts, and the girls were the novices. This hierarchy impacted how they interacted with the adults, with each other, and with the program itself.

These learning exchanges happen within the context of a cultural community. Cultural communities are dynamic in nature and made up of the interaction of individuals within these communities (Rogoff, 2003). A community as defined by Rogoff is a group of people "who have some common and continuing organization, values, understanding, history, and practices" (p. 80). They share a common thread and a history of past experiences. Rogoff makes a distinction between participation and membership in a community. One can participate in a community without being considered a member by the community. This situation is common among middle school student clubs, where a student may participate in the activities but isn't considered part of the 'in group' in the club. These students are outsiders within an organization because they are not accepted by their peers in that organization.

Within these communities, Rogoff (1995) focuses on the cultural processes underway rather than on the cultural groups. She describes three planes of interaction within communities: apprenticeship, guided participation, and participatory appropriation. Apprenticeship is a metaphor used to describe generally the interactions within the community. "The metaphor of apprenticeship provides a model in the plane of community activity, involving active individuals participating with others in culturally organized activity" (Rogoff 1995, p. 143). The focus in this approach to studying communities is the interaction between individuals in that community and the structure that allows novices to become experts once they become part of the community. Guided participation describes the interpersonal interaction between individuals in a community as they participate in an activity. It is a filter through which we can look at interactions within a community (p. 146). "Guided participation is thus an interpersonal process in which people manage their own and others' roles, and structure situations (whether by facilitating or limiting access) in which they observe and participate" (p. 147). This participation refers to both the larger systems that contribute to people's interaction as well as specific instances where people participate together. Using a science club as an example of guided participation, girls choose to participate in an extracurricular program such as a science club. Once they are involved in the club, they participate on multiple levels within the club. On one level, they are participating in the socially constructed idea of a science club. On another level, they work side by side with other girls to solve problems and accomplish other club related activities. Both of these levels are part of their guided participation in the socioculturally constructed science club. By choosing to participate in the club, they have accepted the idea of the club, and through their participation they actively engage in the interpersonal interaction that forms the club community. If their experience in this community is positive, then it is likely that their attitudes toward the activity (science) are positive.

Participatory appropriation describes how individuals change through their participation in an activity. As Rogoff articulates, "…participatory appropriation refers to how individuals change through their involvement in one or another activity, in the process becoming prepared for subsequent involvement in related activities" (Rogoff 1995, p. 150). Rather than focusing on the community as a whole, participatory appropriation focuses on the individual and the internal changes that result from participation in an activity. Through participation, an individual transforms his or her understanding of that activity. He or she becomes responsible for the process and can later participate in similar activities. If we look specifically at adolescent girls, we can study how activities shape them as individuals and how specific activities such as a science club foster or inhibit their growth as individuals.

Rogoff makes a distinction between the terms appropriation and internalization as described by Vygotsky. Internalization is embracing something external, whereas appropriation involves the individual in the process of the activity. The individual contributes to the transformation within appropriation. "The appropriation perspective views development as a dynamic, active, mutual process involved in people's participation in cultural activities; the internalization perspective views development in terms of a static, bounded 'acquisition' or 'transmission' of pieces of knowledge" (Rogoff 1995, p. 153). We see the sophistication of Rogoff's theory in the distinction between appropriation and internalization. Although she uses ideas from the expert/novice model of learning, she sees the novice as an active participant in shaping learning rather than as a passive recipient. Within the science club intervention, it is hoped that students see learning as an active process rather than as a top-down process. This nuance was not specifically explored within the study, but future studies could investigate the idea.

Dewey's ideas about the role of context in learning are similar to both Rogoff and Vygotsky (Dewey, 1933). He supports the role of formal schooling in shaping the learner and focuses on the role of the teacher in the learning process:

> …his [the teacher's] providence is rather to provide the materials and the conditions by which organic curiosity will be directed into investigations that have an aim and that produce results in the way of increase of knowledge, and by which social inquisitiveness will be converted into ability to find out things known to others, an ability to ask questions of books as well as of persons. (p. 40)

The responsibility of the teacher is to help the learner find existing knowledge rather than to find his own knowledge. We see again the expert/novice model where the interaction between the adult and child is a process of leading the child to knowledge rather than collectively creating knowledge within the community. Although both Dewey and Rogoff acknowledge the social nature of learning, they hold on to the traditional notion of experts and novices and the top-down approach to learning.

3.2.2 Role of Experience

Everything that we do is based in experience. The experiences we have on any given day shape who we are and in what we are interested. If we look specifically at what have traditionally been called learning experiences, each one can be viewed as a distinct event that leads the learner or group of learners to a new place and time. People emerge from learning experiences changed in one way or multiple ways. As discussed previously, learning experiences can be studied from different perspectives, such as looking at the role of context and, as will be explored later, looking at learning within the context of self. Learning can be viewed as a situated activity or experience that cannot be removed from the sociocultural experience.

Lave and Wenger (Lave and Wenger, 1991) view learning as a situated activity. They describe a model of "legitimate peripheral participation" where learning is situated within a community of practitioners. Legitimate peripheral participation involves newcomers participating in communities to move toward knowledge and gain skills that will allow them to participate fully in the sociocultural practices of that community. Over time, the newcomer moves toward the center of the community by active engagement in the culture of the community. Eventually, the newcomer becomes a seasoned expert, an old-timer. We can observe this with new members to a science club, where the newcomers are accepted over time into the community that constitutes the club. Sometimes, newcomers are not accepted and do not become part of the community. If the community is accepting of the newcomer, the individual is absorbed into the culture of practice of the community, both becoming part of and helping to create the sociocultural practices. This theory reflects the work of Rogoff, Dewey, and Greenfield (Dewey, 1933; Rogoff and Gardner, 1984, 1999; Rogoff, 1995; Greenfield, 1999; Rogoff, 2003) who all position learning as a sociocultural experience. Within the science club, most of the girls were absorbed into the culture of the community and those who were not likely experienced a very different environment.

Situated learning is extended into the idea of cognitive apprenticeship by Brown, Collins, and Duguid (Brown et al., 1989). They argue that schools typically treat learning as an individual, self-structured experience that teaches the learner abstract, fixed concepts. Their model of cognitive apprenticeship highlights the role of the social experience and the environment in the learning process. "Cognitive apprenticeship methods try to enculturate students into authentic practices through activity and social interaction in a way similar to that evident—and evidently successful—in craft apprenticeship" (p. 38). Learners in this scenario are given a task embedded in a familiar activity and encouraged to find their own solutions to the task by working collaboratively with others. The role of the teacher is as model and coach, guiding the learner within the activity. In a science club for girls, the teacher acts as a coach, helping to guide the problem-based activity. Again within this theory, we see the influence of the expert/novice model put forth by Dewey, Rogoff, Greenfield (Dewey, 1933; Rogoff and Gardner, 1984, 1999; Rogoff, 1995; Greenfield, 1999; Rogoff, 2003). The learner emerges out of the activity as a member of the culture of practice, changed by the experience and also contributing to how others perceive the experience.

Greenfield also looks at the idea of the learning experience and the role of the teacher in the learning process (Greenfield, 1999). She applies Vygotsky's theory of learning specifically to the informal educational setting Greenfield does not specifically define informal, but others define informal as learning that occurs outside the traditional bounds of schooling (Falk and Dierking, 1992; Falk and Dierking, 2000; Falk, 2001; Falk and Dierking, 2002; Falk, 2005). In Greenfield's study, there are examples of how a teacher uses scaffolding to enhance a child's development. The adults are guides in the learning process, hearkening back to Vygotsky, Dewey, and Rogoff's expert/novice model of learning (Dewey, 1933; Vygotsky, 1978; Rogoff and Gardner, 1984, 1999; Rogoff, 1995; Rogoff, 2003). Although the learning is socially constructed, it is not totally determined by the social interaction. It is also influenced by self, gender, and many socially constructed variables.

3.2.3 Role of Self

3.2.3.1 The individual as learner

The role of self in the learning experience can be viewed from many perspectives. Social context and individual experience influence cognitive development of the individual. This section looks specifically at the individual as a learner, keeping in mind that context and experience are recursively related to the role of self. In these theories, the individual is the focus of learning. Although each theory is different, they all focus on what is happening inside individuals that influences how they approach learning and why they approach it the way they do. In each theory, the individual moves from one level to the next as maturation occurs. Each person's movement is different, but the theories provide a general framework for classifying at what level person is operating.

Perry's (1970) Scheme of Cognitive and Ethical Development is structured around an individual's positions and the transition from one position to the next. The first position describes a learner who believes in the omniscience of authority. The authority is always right, and the individual must work very hard to learn the right answers. Most middle school students and specifically those in the science club program would likely fall into this category, as they are in a highly structured school environment where the teacher is the authority. In social settings and often in the home, adults are the authority. In the second position, an individual is able to distinguish between "right" and "wrong" authorities. The self in this case is right, and those who hold opposing views are wrong. The third position is where individuals acknowledge that the "Truth" is something that is being discovered by authorities. It is not a constant. We can see the contradiction between Perry's scheme and that of Vygotsky and Rogoff (Vygotsky, 1978; Rogoff and Gardner, 1984, 1999; Rogoff, 1995; Rogoff, 2003), for example, who believe that experts bring novices to knowledge. Perry's model is very much centered on the learner rather than being a top-down expert/novice approach. Within the science club, learning occurred in a top-down fashion when girls were learning how to do activities and when they were listening to scientific guest speakers. Learning occurred in a learner centered way when students were exploring open-ended hands-on activities and also when they were exploring exhibits during field trips to the Sciencenter and other hands-on locations including some of the field trips to Cornell. Depending on what level of cognitive development an individual was operating, some would be more comfortable with the top-down learning and others would prefer the learner centered activities.

King and Kitchener (2002) propose a seven stage model that is comprised of three levels: pre-reflective, quasi-reflective, and reflective. In the pre-reflective level, there are three stages. In the first stage, knowledge is seen as concrete and true. In the second stage, truth is known by authorities, and in the third stage there is some uncertainty to truth and to authorities. Many adolescents would fall within the pre-reflective level, in that they believe there is one truth and that truth comes from authorities such as a teacher, parent, or other adult. As adolescents move into later teenage years, they may begin to question authority and move from the first two stages into stage three, where they believe that there is some uncertainty to truth. The quasi-reflective level consists of stages four and five. Stage four views knowledge as uncertain because there is always ambiguity, whereas stage five sees knowledge as contextual and subjective because it is filtered through an individual perspective. The final level, reflective thinking, constitutes stages six and seven. In stage six, knowledge is based on individual conclusions using information from multiple sources, and reputable sources (experts) are given more weight. Stage seven knowledge views all knowledge as constructed and open to criticism and change over time as new evidence and information becomes known. We can see the relationship between the social context of learning and the reflective judgment model. This model is based on the idea of the individual being shaped by his or her experience and the relation between the individual and authority, which itself is a socially constructed position.

Similar to King and Kitchener (2002), Schommer (1998) describes a system with four epistemological factors, each with a continuum from less sophisticated to more sophisticated: Fixed Ability (ranging from ability to learn is fixed at birth to the ability to learn can be changed), Simple Knowledge (ranging from knowledge is unambiguous, isolated bits to knowledge is highly interrelated concepts), Quick Learning (ranging from learning is quick or not-at-all to learning is gradual), and Certain Knowledge (ranging from knowledge is absolute and unchanging to knowledge is evolving). These continuums are similar to King and Kitchener's stages. Many adolescents would fall on one side of the continuum in learning situations, seeing the ability to learn as fixed at birth and knowledge as unambiguous and determined by authorities. These students would see learning as being quick or not-at-all and knowledge as absolute. Schommer points out that both age and education affect epistemological beliefs. She evaluates the separate effects of age and education, concluding that "As individuals grow older, they become more convinced that the ability to learn can be improved. The more education adults obtain the more likely they are to believe that knowledge is highly complex and constantly evolving" (p. 557). Schommer concludes by recommending that research with middle and high school students should be undertaken to study the effects of age and education earlier in life.

Like King and Kitchener (2002) and Perry (1970), Belenky et al. (1986) describe a similar model. This model provides “a set of epistemological perspectives from which women know and view the world” (p. 15). It begins with a position of silence, in which women are without voice. This position is very similar to the first position in Perry’s model in which women rely solely on external authority. The next position, received knowledge, corresponds to Perry’s dualist position. Received knowers believe that there is only one right or wrong answer and believe that knowledge comes from others, not from self. Adolescent girls would most likely fall at the first position, silence, or the received knowledge position. Given cultural norms that repress girls, they may not move from the received knowing position into later positions until they break away from authority and begin to look at themselves as authorities. Subjective knowledge places emphasis on authority within the self, and external authority loses power at this position. Subjective knowers believe that truth is personal and subjective and that personal truths have more credibility than external truths. Procedural knowers acknowledge authorities but believe that those authorities have techniques for constructing answers rather than having truths. These knowers focus on procedures, skills and techniques that they need to be able to communicate knowledge with others. Constructed knowledge, the last position, revolves around social construction of knowledge. Constructed knowers “let the inside out and the outside in” (p. 36) and believe that all knowledge is constructed and relative. Dialogue is an important part of constructed knowing, and there is a connection to Vygotsky, Tarule, and Fosnot with the importance of speech and dialogue for social construction of knowledge (Vygotsky, 1978; Tarule, 1998; Fosnot, 2005).

Baxter Magolda's (1992) epistemological reflection model characterizes four ways of knowing which, again, are similar to stages in that the individual moves from one way of knowing to another over time. The four ways of knowing are: absolute, transitional, independent, and contextual. This classification is very similar to that of Perry (1970) and also Belenky (1986). Absolute knowers believe that authorities have the answers and that these answers are not disputable. Many middle school students probably function at the absolute knowing stage, although some may progress into transitional knowers. Transitional knowers move beyond an absolute belief and accept that knowledge can be uncertain. Independent knowers focus on their own thinking and choose to accept or reject other people's ideas. Finally, contextual knowers integrate their ideas with those of others. Baxter Magolda sees gender related patterns in these ways of knowing, in that women tend to show interpersonal, receiving, and interindividual approaches to knowing, whereas men tend to master knowledge with an impersonal and individual approach. Adolescent girls in this model would try to receive knowledge, as opposed to trying to master knowledge. Those that become transitional knowers would be interpersonal in their approach to learning rather than impersonal.

The role of "self" in the learning experience is critically important when studying adolescent girls. At this age, girls are transitioning from one stage of knowing to another and are trying to determine how they fit in with those around them. To be able to understand where girls are coming from, we need to look into their epistemological growth and determine how to best meet their evolving needs. We will next look specifically at how girls learn and some of the important ways that this learning differs from that of boys.

3.2.3.2 Self and learning: Gender differences

It is important to note that as researchers have delved more deeply into learning, they have seen differences in the ways that women and men learn. These differences have led researchers to look at women's development specifically in an attempt to discover in what ways women's development differs from that of men (Belenky et al., 1986; Baxter Magolda, 1992a; Baxter Magolda, 1992b; Wertsch, et al., 1995; Goldberger et al., 1996; Clinchy and Norem, 1998). Women's development is relational, focused on the self in relation to others. A woman's voice or lack of voice is of central importance as she comes to know the world around her. We will look into these perspectives of how women come to know and how they learn.

Many researchers have studied how women approach knowing and learning (Belenky et al., 1986; Brown and Gilligan, 1992; Goldberger et al., 1996; Clinchy and Norem, 1998; Tarule, 1998). Women approach learning as a community of knowers (Belenky et al., 1986; Goldberger et al., 1996; Clinchy and Norem, 1998; Tarule, 1998). They relate to the world around themselves by connecting with others. Relationships are important to women, who approach the world through a sense of connectedness. "Connection and responsive relationships are essential for psychological development and underlie women's knowing" (Brown and Gilligan, 1992, p. 3). Dialogue with others is a critical part of this connection and an important tool of women's development (Tarule, 1998). Tarule, as mentioned previously, builds on Vygotsky's ideas of speech and language and their role in child development. She explores the notion of dialogue as an interpersonal use of voice. Girls need to dialogue with others to form connections that will help them grow and learn. Within the science club, girls are able to connect with each other and with supportive adults.

The notion of women's voice was first introduced by Gilligan (Gilligan, 1982, 1993) and furthered by Belenky (Belenky et al., 1986) and Brown and Gilligan (Brown and Gilligan, 1992). In *Meeting at the Crossroads*, Brown & Gilligan (1992) describe the relational world of girls at the Laurel School. They focus on voice as a critical piece of girls' development into women. "Voice is central to our way of working—our channel of connection, a pathway that brings the inner psychic world of feelings and thoughts out into the open air of relationship where it can be found by oneself and by other people" (p. 20). Voice is a woman's way of connecting with both herself and with others around her to make sense of the world. Girls need to be able to connect with female role models during adolescence to help them find their inner voices.

Brown and Gilligan (1992) note that for girls, adolescence is a period of disconnection from what was previously known and from relationships previously formed. Girls, when they reach adolescence, focus less on relationship with the world around them and more on "relationships." Brown and Gilligan refer to this as "the giving up of relationship for the sake of 'relationships'" (p. 7). The meaningful connections that girls once had with others become second priority as the girls vie for "relationships" that will give them some social or other advantage.

3.2.4 Sociocultural Nature of Science

We have looked extensively at how we learn what we learn and focused on how girls learn. We now turn to exploration of how science is created and how girls can participate in the social construction of scientific knowledge. If we are able to encourage girls to participate in this sociocultural experience, then they will shape the future directions of science and more broadly the world around us. Harding (Harding, 2001) offers the idea that women's involvement in the creation of scientific knowledge can improve science. She states, “Looking at nature and social relations from the perspective of these conflicts in the sex/gender system…has enabled feminist researchers to provide empirically and theoretically better accounts than can be generated from the perspective of the dominant ideology” (p. 152). She argues that the feminist perspective in science allows for better science to emerge. Women’s perspective and ways of approaching learning are different from those of men, and therefore if more women in the future are involved in creating science, science will inevitably be different from what it is today.

Along the same vein, Keller (1987) points out that the difference that women bring to the table allows for new perspectives within the scientific process. She states, “the conditions arose for some feminists, in the late 1970s and early 1980s, to begin to argue for the inclusion of difference—in experience, perceptions, and values—as intrinsically valuable to the production of science” (p. 236). Women, through their experience, perceptions, and values that are inherently different from those of men, can improve science by offering new perspectives in the production of scientific knowledge. Women see the world differently, as previously noted in Belenky’s study of women’s epistemology. They see the world as a web of connections and through these connections are able to create knowledge that is different from knowledge that is created without these connections.

Similarly, Haraway (1991) describes the social construction of scientific knowledge and looks specifically at objectivity. She believes that women, through their vision, create knowledge that is different from that of men. “I would like a doctrine of embodied objectivity that accommodates paradoxical and critical feminist science projects: feminist objectivity means quite simply situated knowledges” (p. 188). She continues later, “I want a feminist writing of the body that metaphorically emphasizes vision again, because we need to reclaim that sense to find our way through all the visualizing tricks and powers of modern sciences and technologies that have transformed the objectivity debates” (p. 190). The modern sciences and technologies “see” the world through a male dominated point of view, as they were developed by a masculine scientific enterprise. If women participate in the scientific process and provide their vision and ideas, then modern science will be reshaped to reflect the diversity and richness of perspective that comes with women’s contribution to knowledge creation. If this occurs, then increasing numbers of women may be drawn into science because it will be a more connected, interpersonal experience than is often found in today’s scientific laboratories.

Barad (1998) discusses the “intra-action” of science and agential reality and relates these concepts to feminist studies. “Agential realism is an epistemological and ontological framework that provides an understanding of science as ‘material-discursive’ practices” (p. 2). There is an important connection in this framework between the objects being studied and the subjects studying them. The objects and agencies of observation are inextricably bound together, and they intra-act together to form new knowledge. Through this framework, we can see that a female perspective in the scientific process changes the nature of scientific knowledge. Females, with their unique perspective, influence the intra-action of which they are a part.

The role of self in how girls learn science is important because of the changes that occur in girls as they reach adolescence. Brickhouse (2001) discusses the importance of self-concept and identity in teenage girls. “We need to understand how students are constructed and construct themselves as girls, as a member of a particular racial or ethnic group, as a ‘good’ girl, as an athlete, and how these identities overlap in important ways with students’ aspirations regarding scientific identities” (p. 287). Brickhouse is in agreement with Haraway and other feminist writers, who believe that knowledge is socially constructed and that individuals are socially constructed through participation with the world around them. This reinforces the idea that the environment is a critical component in helping girls mature and develop physically and intellectually. In her closing remarks, Brickhouse advises that we need to understand how gender shapes learning.

> Theories of learning that split the person into thinking/feeling, mind/body too often diminish feminine-related attributes and reinforce dualisms feminists are trying to overcome. Furthermore, they limit our understanding of what learning is. A feminist perspective on learning should account for the ways in which gender shapes learning. (p. 290)

Gender, as described by Brickhouse and Belenky et al. (1986), is an important factor in determining epistemological growth. The tendencies of women to connect thought with emotion in their lives and to approach problems as connected knowers directly impacts women’s development.

Applying the theories of epistemological growth to subject areas, Schommer and Walker (1995) undertook a study among college students to determine if their epistemological beliefs were similar across domains. They found that indeed, there were not significant differences across domains. “The results of this study provide support for the underlying assumption that epistemological beliefs are predominantly similar across domains” (p. 429). Bell and Linn (2002) argue that epistemology is domain-specific, as evidenced in their study of student perceptions of science. Their study “stands in contrast to developmental accounts that view epistemological sophistication as domain-general and uniform" (p. 322). They study the impact of instructional techniques on student perceptions of inquiry-based science and conclude that the teacher and classroom have a strong effect on the sophistication of student perceptions. "Clearly students express more sophisticated ideas after studying a science discipline, but the causes of this epistemological sophistication appear closely aligned with instruction" (p. 343). This indicates that epistemological development is tied to the sociocultural experience of learning that occurs in the classroom.

3.3 Conclusion

It is difficult to separate out context, experience, and self as separate factors that influence how we come to learn what we learn because they are intertwined. Each affects the other, as we struggle to make meaning of the world around us. As individuals, we are each at the heart of the learning process, but how we interpret that process is itself open to interpretation as we have seen in this exploration. Many factors influence how we learn, including age, gender, and socioeconomic status. Looking specifically at gender, we see that women and men approach learning in different ways. Adolescent girls approach their interactions with others in interesting and unique ways, and these approaches impact their communication with others and ultimately how and what they learn. We can use this knowledge as a foundation as we work with girls to help them pursue their interests, whether those interests are science or any other topic.

The above synthesis of various views of how we come to learn what we learn is intended to frame the study of girls' attitudes toward science in the context of how girls come to learn about themselves and the world around them. How do they interact with that world, and how does its social construction influence their approaches? Clearly, there is much room for studying the phenomenon underlying girls learning and also a critical need for studying the interaction of gender and learning in the area of science. It is my hope as a researcher that we will explore these ideas as we move the field forward and help girls come to understand themselves and their place within a larger context.

CHAPTER 4

METHODS

4.1 Previous Research Designs to Measure Attitudes Toward Science

4.1.1 Quantitative Studies of Attitudes Toward Science

Attitudes toward science are measured through two basic approaches. The first and most prevalent is an attitudinal survey with corresponding scales. In their history of science attitude assessment scales, Misiti, Shrigley and Hanson (1991) summarized the history of various instruments and then proposed a revised, validated Likert science attitude scale for middle school students. They surveyed scholarly journals and concluded that very few authors detail the design of their scales. Exceptions were Simpson and Oliver (1985), Wareing (1982), Hough and Piper (1982), Fraser (1978), Perrodin (1966), and Fisher (1973).

Fraser (1978) developed the Test of Science Related Attitudes (TOSRA), a 70-item instrument containing seven scales with ten items per scale. These seven scales are based on Klopfer's (1971) "conceptually distinct categories for the effective domain in science education" (Schibeci, 1982, p. 567). To create the instrument, Fraser involved science teachers in the process of selecting items from a large pool to fourteen items per subscale. He then field-tested the instrument with high school students to narrow the number down to ten items per subscale. Fraser revised and republished TOSRA in 1981. As described by the author,

> This 70-item, 5-point, agree/disagree scale was designed to measure seven distinct science-related attitudes of secondary school students. These scales measure Social Implications of Science, Normality of Scientists, Attitude to

> Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science (Fraser, 1981).

One of the strengths of this instrument is its ability to provide separate scores for each subtest or attitudinal component. Researchers may elect to group scores together but may also look at individual scores. The norm sample on which this instrument is based contained 1,337 students in Sydney, Australia during grade levels seven through ten. According to technical information contained in Fraser (1981),

> Internal consistency via Cronbach's alpha ranged from .64 to .93 across subscales and grades in Australian schools and from .68 to .91 for a sample of grade nine girls in two urban Catholic schools in Philadelphia. Discriminant validity for TOSRA is discussed based on the uniqueness of each subscale since scale intercorrelations were low at a range of .10 to .59. The internal consistency and validity of this instrument make it suitable for use in attitudinal studies.

TOSRA uses a five-point Likert scale with the categories Strongly agree (SA), Agree (A), Not sure (N), Disagree (D), and Strongly disagree (SD). As noted in Fraser (1981), "An important feature of Likert-type items is that their intention is often obvious to the test respondent and, therefore, it is possible for the responses to reflect opinions which are more positive or more negative than they really are" (p. 2). It is important to keep this possibility in mind when analyzing data from a TOSRA study. However, if a large sample size is used and scores are grouped together, the impact of a few students faking answers would not be significant. Also, as suggested by Fraser, "…the likelihood of faking could be further reduced by making responses anonymous" (p. 2). Anonymity is important in any attitudinal study to protect the privacy of respondents, but sometimes names are needed for tracking changes in attitudes on an individual basis or when tracking is needed to identify students in a group who will participate in an intervention.

In addition to the Likert technique employed by many researchers, another option is the semantic differential (SD) technique. Schibeci (1982) devised a SD instrument to measure student reactions to eight stimuli: Science in society, Science lessons, Science career, Science hobbies, Scientific attitudes, Scientists, Science teacher, and School. As described by Schibeci,

> Respondents are asked to provide reactions to the concepts by means of a set of bipolar adjective pairs. These were: exciting—boring, worthless—worthwhile, easy—hard, dull—interesting, important—unimportant, complicated—simple, useless—useful, enjoyable—unenjoyable, gloomy—joyful, clear—unclear….Each adjective pair is separated by a five-point scale, usually five boxes. Students check one of these five boxes which are then assigned scores of 1, 2, 3, 4, and 5, respectively. (p. 566)

In his 1982 study, Schibeci field tested TOSRA and his SD instrument to provide a comparison of the two approaches in measuring attitudes of students in grades eight through ten. He concluded that TOSRA was more effective at measuring specific attitudes toward science and that the SD instrument was suitable for measuring general attitudes toward science. "Discussion with students who responded to each instrument indicated that the SD format allows an assessment of general attitudes to concepts such as 'school' and 'science'. The Likert format used in TOSRA, on the other hand, allows a more fine-grained assessment of specific attitudes" (p. 568).

Friend (1985) studied attitudes toward science and scientists of students in Queens, New York. He used The Science Attitudes Appraisal, a sixty item instrument with four sections.

> The first section appraises the Adoption of Scientific Attitudes (30 items and a maximum score of 150). The second section appraises Attitudes Toward Science (10 items and a maximum score of 50). The third section appraises Attitude Toward Scientists (10 items and a maximum score of 50). The final section appraises students' Enjoyment of Science Learning Experiences (10 items and a maximum score of 50). The optimum score is 300 on the Likert-type scale. Each section's items have reverse polarity, so that one-half of the items has the highest numbered choice (5) as the response with the greatest value, while one-half of the items has the lowest number (1) as the response with the greatest value. The entire Appraisal has a reliability (Coefficient Alpha) of .87. (p. 455)

The reliability of this instrument is high, but it is limited in that it explores general attitudes toward science, whereas the TOSRA measures specific attitudes. Likewise, Friend's instrument measures only three of the six categories in Klopfer's taxonomy (A, C, D), but the TOSRA measures all six (A, D, E, F for attitudes toward science and B, C for scientific attitudes).

Peterson and Yaakobi (1980) studied self-concept, which is directly related to attitude toward science, using the Peterson-Yaakobi Q-Sort (PYQS). Two hundred ninety-three students were sampled from two different states. Self-concept was the dependent variable, and demographic data including type and level of course, science letter grade from the previous semester, and gender of student were independent variables (p. 170). The PYQS contained twenty science student behavior statements that each student arranged twice, once to describe an ideal science student and once to describe him/herself as a science student. Peterson and Yaakobi found that there were no gender differences in terms of self-concept. "It may be that while females do have different orientations toward science and science-related careers than do males, a general more positive relationship with school tasks and settings continues to compensate in terms of overall self-esteem" (p. 173). Particularly unique to this instrument design is the students' classification of statements containing both positive and negative behaviors.

Simpson and Troost (1982) provided thorough documentation of the process used to design their ten-year longitudinal study with 4500 middle school students. They stated, "Early in the investigation we discovered that existing instruments designed to measure attitudes and achievement were not suitable for this project because of reading level, item complexity, and low internal consistency reliability" (p. 771). These researchers undertook a project to develop three different instruments: attitude questionnaires for students, criterion-referenced achievement tests in science, and attitude questionnaires for teachers involved in the study. They developed twelve questionnaires during the 1979-80 school year. Variables studied were science, family, self, and school. A five-member expert panel of sociologists and science educators reviewed items, which were also analyzed by constructing a correlation matrix and through factor analysis. Internal consistency reliability was required for an item to remain in the instrument. The final instrument contained sixty items arranged in fifteen subscales, and the teacher instrument contained twenty-six items (p. 773-4). Advantages of the study design outlined by Simpson and Troost include the large sample size of 4500, the racial and socioeconomic heterogeneity of subjects, diverse geographical origins, and the longitudinal nature of the study (p. 777).

Numerous studies co-authored by Simpson utilized the instruments developed in 1979-80 and its resulting data sets. Studies include the aforementioned work of Simpson and Troost (1982), Cannon and Simpson (1985), Simpson and Oliver (1985), Talton and Simpson (1986), Oliver and Simpson (1988), and Simpson and Oliver (1990). Each study focused on a unique hypothesis involving attitudes toward science. The overall study design, including its instruments, was effective in answering several key research questions.

Cannon and Simpson (1985) hypothesized that there is a relationship between attitude, motivation, and achievement in ability grouped seventh grade life science students. They found that indeed, relationships exist between attitude, motivation and achievement and that there are differences between genders. This study also found that the middle ability students (called “general”) had the sharpest decline in attitude and achievement during the seventh grade year (p. 134-5).

Similarly, Simpson and Oliver (1985) looked at attitudes toward science and motivation to achieve in science over the school year and across grades by gender. This analysis found that attitudes toward science within this population steadily declined from grade six to grade eight (p. 521) and that the sharpest decline occurred from grade seven to grade eight. As in the former study, males exhibited more positive attitudes toward science than females, and attitudes toward science of all students dropped from the beginning of the year to the end. Interestingly, females were more motivated to achieve in science than their male peers, even though their attitudes were lower.

When Talton and Simpson (1986) studied the data from this ten-year period, they asked two questions: (1) “What is the contribution of each category of variables; self, family, and classroom environment to attitude toward science?” and (2) “Of the entire set of variables, which show the strongest relationship with attitude toward science?” (p. 366). They found that the three categories of variables were significant predictors of attitude toward science. Therefore, self, family and classroom environments have a positive relationship with attitudes toward science.

Oliver and Simpson (1988) turned again to the longitudinal data to determine if attitude toward science, achievement motivation, and science self-concept predict achievement in science. They also wanted to determine if science achievement was correlated to achievement in other subjects. This study found that achievement motivation and science self-concept were predictors of achievement in science and that attitude was less likely to predict science achievement (p. 153). Based on these findings, Oliver and Simpson concluded that self-concept is a critical part of increasing science achievement.

A final article published using the instrument and data from the ten-year longitudinal study by Simpson and Troost was a summary of findings including a follow-up to the original study. "This longitudinal follow-up was designed to assess the degree to which earlier measures of attitude and achievement variables could be used to predict later achievement and participation in science" (Simpson, Oliver, 1990, p. 11). Design of the follow-up was a random sample of students from graduating classes. A records search was undertaken to find information on number of science courses taken, number of other courses taken, grades made in science and other courses, participation in science fairs and clubs, and standardized test scores. The results of this follow-up were not detailed in the article, but Simpson and Oliver state, "Two important parts of the work emerged. It was shown that under certain conditions both achievement and participation in later science courses could be predicted from earlier reports of affect" (p. 11). The "certain conditions" are not explained, and no specific data is given.

Turning to a different attitudinal scale, the scale of choice by Misiti (1991) was the 33-item Likert scale designed by Shrigley in 1968. Shrigley used the scale to measure the effects of handmade and commercial science equipment on science attitudes of sixth grade students. The researchers redesigned this scale to make the attitude object more general and piloted it with several hundred students in grades four, five and six. For purposes of this study, the target population was 206 fifth through eighth graders. Misiti embedded the attitude object, namely learning classroom science in the middle school, within each trial statement. They also engaged a jury of elementary science teachers and middle school students to review the statements before implementation. Based on several criteria including reliability, 23 statements were chosen for the final version of the scale. The resulting scale has internal consistency, evaluative quality, known groups validity, and cross-cultural validity (p. 534-538).

Sidlik and Piburn (1993) pursued the question of the relationship between enablement, alienation, and attitude toward science in grades seven and eight. The study contained a survey of 2,159 students in 19 classrooms and 4 middle schools in a suburban white community. Two existing instruments were combined and revised into one forty item instrument. The first instrument revised was the Individual and Group Attitudes Toward Science (Piburn et al., 1992) along a ten-point Likert scale. Twenty items were selected from this longer instrument, and the Coefficient alpha was 0.67. The second instrument revised for this study was the Measure of Classroom Structure (Baker et al., 1992), consisting of two subscales, one measuring students' feelings of empowerment in classroom decision making and the second measuring students' feelings of insecurity and competition in the classroom. Coefficient alpha for the first scale was 0.76 and for the second was 0.54. The combined instrument, My Science Class, was created by randomly combining items from these two instruments (Sidlik and Piburn, 1993, p. 12). This study contained many significant findings, one of which relates to the current study about female attitudes toward science. "There are no significant differences in the attitudes of male and female students toward science. However, students of female teachers have a significantly better attitude than those in classes taught by males, $F(1,2158)=13.93$, $p=.0002$" (p. 15). Female science teachers may act as positive role models for girls, encouraging their positive attitudes toward science.

The 20-item Attitude Survey for Junior High School was developed by Fisher (1973). Fisher's scale was developed by science curriculum specialists and contained item-total correlations from 0.18 to 0.76. Test-retest and split-half reliability tests generated r-values of 0.793 and 0.833 (Misiti, et al, 1991, p. 526). Harty, Andersen, and Enochs (1984) used a modified version of Fisher's survey for elementary students and called it Children's Attitude Toward Science Survey (p. 310). In a trial with 171 fifth graders, they reported internal consistency reliability with alpha coefficient of 0.78 and split-half reliability with alpha coefficient of 0.76. Test-retest reliability was 0.55 with $p<.05$ (p. 311). Harty, Beal, Scharmann (1985) reported using this instrument to explore relationships among elementary school students' interest in science, attitudes toward science, reactive curiosity, and scholastic aptitude. "An analysis of the data revealed that a potential relationship or shared common variance exists between the criterion variable of science achievement and the predictor variables of attitudes toward science, interest in science, reactive curiosity and scholastic aptitude" (p. 475). They conclude that the classroom environment impacts science learning as related to aptitude and attitude: "Teachers can create classroom environments where science learning can be increased, scholastic aptitude enhanced, and attitudinal tendencies fostered" (p. 478).

4.1.2 Qualitative Studies of Attitudes Toward Science

Significant attitudinal research has used a quantitative approach, and less research has been documented on qualitative studies for determining attitudes toward science among middle school students. One such study by Piburn and Baker (1993) points out the limitations in methods used to measure attitudes toward science.

> There are two problems inherent in most attitude scales. First, paper and pencil measures, however well constructed, are limited in the amount of information they can yield. They allow only a narrow range of response and do not provide the opportunity for thoughtful exploration. Second, and perhaps more significant, is the fact that these instruments are constructed from the perspective of the adult who is engaged in research. (p. 393)

Quantitative scales do not allow students to respond freely with their thoughts, and they are biased in their construction because adults write the statements with a research agenda in mind. Piburn and Baker assert that research grounded in student perceptions is useful in studying factors that contribute to attitude toward science. They present an alternative method of assessment, interviews, to gauge student attitude toward science.

The study implemented by Piburn and Baker used a random sample of 149 students (83 elementary, 35 junior high, 31 high school) in one school district, with equal numbers of males and females represented. The study was described thus:

> Interviews were conducted using a semistructured protocol that allowed changes in language to suit the age of the subject as well as permitting interviewers to pursue interesting or idiosyncratic student responses that seemed likely to give further insight into the origins of attitude. Questions were designed to assess trends or changes in attitude and identify factors affecting attitude. To this end, open-ended questions were asked that would

> reveal feelings about: (1) attitude toward science and school; (2) instructional techniques, materials, and activities; (3) the nature of science and scientific work; and (4) academic and career goals in science. A final line of questioning, which often proved most productive was… 'If YOU were the teacher, what would you do in your science class?' (p. 395)

Interviews were transcribed, and responses were grouped into three themes: instructional strategies, cognitive demands, and students' ideas about how science should be taught (p. 396). Findings included isolation as a factor in declining attitudes toward science as students progressed through school. "Our analysis suggests that a major factor in the decline in the attitude toward science was the increasing isolation students experiences as they moved through the grades. As the number of opportunities for student—student and student—teacher interactions, both academic and social, declined, negative attitudes toward science increased" (p. 403). This data provides support for intervention programs that allow for increased interaction between teacher and student and between students.

Analyzing their results one step further, Piburn and Baker quantified their data by developing a set of twelve categories based on student responses and then using coding by two readers to classify responses into the categories. A discriminant analysis was performed, and three discriminant functions emerged. "The first [discriminant function] accounted for 44%, the second for 36%, and the third for 20% of the variance across grade levels. These three discriminant functions allowed the correct classification of all (100%) subjects by grade level" (p. 404). This analysis shows statistically significant grade-level difference in student responses, but as stated by the researchers, "…it does not approach the richness and authenticity of the qualitative analysis" (p. 405). Qualitative analysis allows insight into student perceptions that is missing from quantitative scales.

Ledbetter (1993) conducted a similar study with 2,160 subjects (1088 female, 1072 male) to assess secondary students' views of science through their operative definitions of science. "It is important for students to describe science in their own words, without excessive adult interpretation…" (p. 611). Similarly, Piburn and Baker cited adult bias as a reason to avoid Likert-type scales when studying student attitudes toward science. Ledbetter used an emergent research design that included document review of 2160 statements, participant observation of students in 22 classes, and interviews with 45 students (p. 614). The documents studied were index cards on which students wrote their definition or view of science. These cards were sorted into twenty-seven groups of similar answers. After further analysis, six categories emerged: Discovery, School-Centered, Phenomena and Their Actions, Thinking Activities, Scientific Method, and Other. A greater percentage of middle school students perceived science as a school related activity (30.8%) rather than as discovery (27.6%) (p. 617). Gender differences were minimal, but the observation and interview portions of the study found that females were reluctant to show their skills in science (p. 618). Also notable in this study was that almost 500 (roughly a quarter) of students viewed science as School Centered, and students interviewed did not think science was useful in their daily lives (p. 620). Disappointingly, not much information was provided on the interview or observation portions of this study other than inclusion of anecdotal statements within the discussion.

Harwell (2000) also used interviewing in her study of 655 students in grades six through eight at four schools to gain perspective into student perceptions about science and learning. The strategy was "creative interviewing", which consisted of "a short, structured student/peer interview protocol patterned after the work of Fullan (1994) and written in a language suitable for middle level students…” (p. 224). The protocol included the following questions: (1) What is a successful learner? (2) Do you consider yourself a successful learner? (3) Why do you say this? (4) What is science? (5) How do you learn science best? (6) What are teachers and the school doing to help students learn about science? (7) What do you wish your teachers and your school were doing to help you learn science? (p. 224). Seventh grade girls’ responses (N=215) were separated from the general pool of data to analyze their perceptions of science learning. Cluster analysis was used to categorize the responses, and five major clusters emerged: perceptions of self-as-learner, perceptions of the nature of science, perceptions of classroom learning environments conducive to learning science, perceptions of current teacher actions to assist science learning, and girls’ wishes to improve science learning (p. 226). Although several aspects of this study are useful in studying attitude toward science, the notion that girls prefer active engagement in science to passive learning applies to the current study. “These girls showed a strong preference for hands-on learning activities, experimentation, and problem solving; furthermore, they believed these strategies were useful in learning science” (p. 235).

Building upon this previous work, the study herein used both quantitative and qualitative instruments to explore girls’ attitudes toward science. Interviews, surveys, and tests were used at three time points during the school year to gather information about what influences student attitudes toward science. This mixed methods approach allowed for rich data collection at several time points to produce a picture of girls’ learning and attitudes during the course of a school year. We will now delve into the overall design of the study.

4.2 Overview of Quasi-experimental Design

The study features a quasi-experimental design based on two overarching research questions:

1. Do attitudes toward science change during the course of the school year in grades seven and eight?
2. Does a science club for girls influence girls' attitudes toward science in grades seven and eight, and is there a difference in attitude change between grades seven and eight?

A nonequivalent groups design was implemented to collect data related to these research questions and their corresponding hypotheses, and descriptions of the design and the specific hypotheses investigated appear below.

4.2.1 Nonequivalent Groups Design

The design of a study is critical to ensure that the outcomes can be attributed to the treatment with some degree of accuracy. Several approaches can be used to set up a study that will have internal validity. Internal validity is "the validity of inferences about whether the relationship between two variables is causal" (Shadish et al, 2002, p. 508). When implementing a nonequivalent groups design, it is important to specify the threats to internal validity and then rule out each threat individually. In this way, the researcher can rule out plausible threats to the validity and arrive at a reasonable conclusion.

Quasi-experimental designs use nonrandom assignment and are therefore plagued with difficulty (Shadish et al., 2002, p. 14). However, they are very common in social science research and are the design of choice for the study underway to determine attitude changes toward science in seventh and eighth grade girls. Shadish, Cook and

Campbell (2002) advocate the use of structural design features from the theory of experimentation instead of reliance on statistical modeling features to compensate for the weaknesses inherent in quasi-experimentation. They believe that good experimental design features will lessen the need for statistical adjustments to data. In experiments with nonrandom assignment to treatment conditions, it is important to incorporate four features to determine causality:

1. variation in the treatment
2. posttreatment measures of outcomes
3. at least one unit on which observation is made
4. a mechanism for inferring what the outcome would have been without treatment (the "counterfactual inference"). (p. xvii).

The study of girls' attitudes toward science includes all of the above, as elaborated below.

Variation in the treatment occurs through a switching replications design. There are two treatment groups: girls in grade 7 and girls in grade 8. Both of these treatment groups participate in a science club for girls from October through May. At mid-year, the two treatments switch, so that participants experience both treatments. Also at mid-year, data is collected to determine if there exists a change in attitude at mid-year that it correlated to the treatment itself. Switching replications between grades 7 and 8 allows the one type of treatment to be used as a control for the second type of treatment (Shadish et al., 2002, p. 146). If there is a decline in attitude between pretest and midterm test for those receiving one treatment (e.g., hands-on) and then the attitude goes up during the second treatment (e.g., careers), then we can infer that the hands-on caused a decline in attitude while the careers caused an improvement in attitude. We can also compare the treatment group with the control group at mid-year and at post.

Posttreatment measures of outcomes are important to provide data that reflects participant changes as a result of treatment. In the study referenced herein, posttreatment measures are embodied in multiple instruments including an attitudinal test, a survey, and an interview. The mixed methods approach to posttreatment data collection will provide triangulation of data for a more accurate portrayal of treatment effects.

There are two treatment units on which observation is made in this study. The first treatment unit is grade 7 girls who have elected to participate in the science club, and the second treatment unit is grade 8 girls who have elected to participate. The treatment groups in the study include all seventh and eighth grade girls and boys who do not participate in the science club. Data can be compared within units, across units, and between the units and the control groups.

Inferring outcomes that would have occurred without treatment is the most complex portion of the study. It is difficult to determine differences between the treatment subjects and the control subjects, as the treatment subjects self-selected to participate in the treatment. Within any nonequivalent groups design, it is important to establish initial differences between the treatment group and the control group so that an accurate outcome comparison can be drawn. "In nonequivalent control group designs, therefore, it is imperative to explore the reasons for initial group differences, including why some groups assign themselves or are assigned to one treatment rather than to another" (Shadish et al., 2002, p. 143). Pre-test data can be used to establish a baseline of information. If the baseline data is comparable between, for example, seventh graders who choose to participate and seventh graders who choose not to participate, then we can infer that the two groups are somewhat similar at pre-test. Ideally, two pre-tests administered at two different points before implementation of treatment would have been a better scenario (Reichardt, 1999; Shadish et al., 2002). It is not impossible to rule out the selection bias threat to validity, but it will be a greater challenge given that there is only one pre-test data set to use.

Three requirements for causal relationships are: "that cause precede effect, that cause covary with effect, and that alternative explanations for the causal relationship are implausible" (Shadish et al., 2002, p. 105). Given that the study is a nonequivalent groups design, it will be difficult to rule out alternative explanations. However, if the study is properly designed the researcher can rule out most threats to validity and feel confident in the conclusions.

The design of the study is similar to that proposed by Shadish, Cook and Campbell (see study design below). The first two rows represent the treatment groups, grade 7 science club participants, and grade 8 science club participants, respectively. The third and fourth rows represent the control groups, grade 7 non-science club participants (both male and female) and grade 8 non-science club participants (both male and female), respectively.

O_1 is the implementation of the TOSRA in October, 2003 before treatment began, then again in February, 2004 before switching replications of the two treatment groups, and then in June, 2004 after the treatment was administered to the two treatment groups. O_2 is the implementation of pre, mid, and post-surveys administered within days of the TOSRA for those who participated in the treatment. O_3 is the implementation of post-interviews at the end of the school year for those who participated in the treatment. X_1 is treatment one, a hands-on science club for girls. X_2 is treatment two, a career and role modeling club for girls.

Table 4.1 Study design

Gr 7 Club	O_1 O_2	X_1	O_1 O_2	X_2	O_1 O_2 O_3
Gr 8 Club	O_1 O_2	X_2	O_1 O_2	X_1	O_1 O_2 O_3
Gr 7 No club	O_1		O_1		O_1
Gr 8 No club	O_1		O_1		O_1

4.2.2 Mixed Methods

The study used a mixed methods approach to achieve both statistically significant findings and allow for exploration into what causes changes in girls' attitudes toward science. Scales, also known as tests, were administered to explore the hypotheses using quantitative data. In addition, interviewing and surveys containing free response items were important components within the study.

As shown in attitudinal research, attitudes toward science decrease from the beginning of the year to the end of the year during grades 7 and 8 for both males and females. To counteract this normal decline in attitudes among young women, a science club for girls was implemented in a rural school in Central New York. All students in grades seven and eight participated in the study, as did the two science teachers responsible for science instruction for all seventh and eighth graders. Female students were invited to participate in an intervention program, a science club for girls, at the beginning of the year. Female students who self-selected to participate in the science club comprised the treatment group for the study. Male students and female students who chose not to participate in the science club comprised the control groups.

This study is a classic Nonequivalent Groups Design with pre-, mid- and post-surveys of participants. Female students who self-selected to participate in the science club for girls participated in the intervention treatment. The students were divided into two treatment groups by grade level (grade seven, grade eight) to prevent cross-grade level dilution of treatment effects. One treatment group participated in a hands-on science club for the first half of the school year followed by a career/role modeling science club for the second half of the year. The second treatment group participated in a career/role modeling science club for the first half of the year followed by a hands-on science club for the second half of the year. The study utilized switching replication at mid-year (February) to improve internal consistency and eliminate normative effects on the population studied.

The science club was designed with three overall programmatic goals:

1. Provide a forum for girls to interact with each other and with supportive female mentors
2. Get girls excited about science through hands-on activities and field trips
3. Provide role models to encourage girls to consider science as a career option

Club meetings at the school occurred once per month for each grade level. For the hands-on treatment, activities were focused around a theme of electrical circuits and included: Build a Simple Circuit, Build a Parallel Circuit, Build a Series Circuit, Create a Battery Out of a Lemon, Light Up Light Emitting Diodes, and Build a Digital Thermometer. These activities were led by the researcher and the teacher mentors for the club. It was expected that this treatment would impact the following TOSRA subscales: Social Implications of Science, Normality of Scientists, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, and Leisure Interest in Science.

For the career/role modeling treatment, guest speakers from Cornell University were invited to talk about their research and about how they got involved in science. These young women included a chemist, a biologist, a biochemist, and a materials scientist. Each scientist gave a ten to fifteen minute presentation that included how she got involved in science and what her current research involved. These presentations were followed by question and answer sessions with refreshments.

Additionally, each month students were invited to field trips that included hands-on activities at Cornell University, the Sciencenter of Ithaca, and IMR Test Labs (a local materials testing company). These field trips combined students in grades seven and eight as well as students from two other science clubs for girls at two other rural schools. The total attendance at field trips ranged from seventy-five to ninety-four girls, and on average over half of these girls were from the school under study. Activities at Cornell University included Holey Cow, Virtual Reality, Engineering Explorations, and Hydroponics. The Sciencenter field trip provided the opportunity for girls to explore over two hundred hands-on exhibits, while the IMR Test Labs field trip allowed students to meet female scientists in their workplace. It was expected that this treatment would impact some of the same TOSRA subscales as the previous treatment: Social Implications of Science, Normality of Scientists, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Leisure Interest in Science, and

Career Interest in Science. When combined, it was expected that the two treatments would impact overall scores on the TOSRA test as well as scores within each subscale.

4.3 Research Questions

The study explored two research questions and four distinct but related hypotheses, which are detailed below with their corresponding methods.

Research Question 1: Do attitudes toward science change during the course of the school year in grades 7 and 8?

Hypothesis 1: Attitudes toward science among students in grades 7 and 8 will decrease during the course of the school year.
The TOSRA was administered at the beginning, middle, and end of the school year to all students in grades 7 and 8 (See Appendix A). Each of the seven attitudinal scales was analyzed within grades 7 and 8, respectively, and as a collective. It was expected that when results were pooled, student attitudes toward science in both grade levels would decrease during the school year. The reliability of this portion of the study is high, as all data is quantitative and the sample size is over one hundred.

Research Question 2: Does a science club for girls influence girls' attitudes toward science in grades 7 and 8, and is there a difference in attitude change between grades 7 and 8?

Hypothesis 1: Girls who self-select to participate in the science club for girls will have higher attitudes toward science at beginning, middle, and end of the year than girls who choose not to participate.

TOSRA data for each of the seven subscales was pooled together and compared between girls who self-selected to participate in the science club and girls who chose not to participate. It was expected that girls who self-selected to participate in the science club would have higher attitudes toward science on each of the seven subscales than those who chose not to participate. It was also expected that this trend would be observable at beginning, middle and end of the year. Again, reliability of this portion of the study is high, as the sample size is over one hundred.

Hypothesis 2: Intervention in the form of a hands-on science club will maintain or increase girls' positive attitudes toward science.

TOSRA data for each of the seven subscales was pooled together for girls who self-selected to participate in the science club for girls. It was expected that attitudes toward science of girls who self-selected to participate in the science club would remain the same or increase during the course of the school year. Reliability of the TOSRA data is not as high as in the previous hypotheses, as the sample size reduced to approximately half, representing the number of girls who self-selected to participate in the club.

Hypothesis 3: For all participants studied, there will be a greater change in attitude at grade 7 than at grade 8.

TOSRA data for each of the seven subscales was pooled and compared between students in grade 7 and grade 8. It was expected that there would be a greater negative total change in attitude for students in grade 7 than in grade 8.

To gain a deeper understanding of the self-selection that occurred among these girls and to provide supportive evidence, surveys and interviews were implemented.

Details regarding these instruments and the data collection timeline are outlined below.

4.4 Quantitative Measure: TOSRA

The mixed methods approach to this study allowed for collection of both quantitative and qualitative data in support of the four hypotheses. Methods utilized were tests, surveys, and interviews.

Quantitative data was gathered through implementation of the Test of Science-Related Attitudes (TOSRA). TOSRA measures eleven distinct science-related attitudes and was specifically designed for secondary school students. Scales included in the TOSRA are: Social Implications of Science, Normality of Scientists, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Learning, Leisure Interest in Science, and Career Interest in Science. These scales correspond to Klopfer's classification scheme for goals of science education (Fraser, 1981, p. 5, see below).

Table 4.2 Scales corresponding to Klopfer classification, from Schibeci, 1982

Scale name	Klopfer classification
Social Implications of Science (S) Normality of Scientists (N)	Manifestation of favourable attitudes towards science and scientists
Attitude to Scientific Inquiry (I)	Acceptance of scientific inquiry as a way of thought
Adoption of Scientific Attitudes (A)	Adoption of 'scientific attitudes'
Enjoyment of Science Lessons (E)	Enjoyment of science learning experiences
Leisure Interest in Science (L)	Development of interest in science and science-related activities
Career Interest in Science (C)	Development of interest in pursuing a career in science

TOSRA contains seventy statements, ten for each scale (see Appendix B). To determine validity of the instrument, Fraser administered the test to 1,337 economically and geographically diverse students in 44 classes from 11 schools. The samples contained approximately equal numbers of males and females and were drawn from grades 7, 8, 9, and 10. Each grade level reported similar means on each scale and comparable standard deviations per scale. Reliability was measured using the Cronbach alpha coefficient and ranged from 0.66 to 0.93. Fraser notes that, "These values for the reliability coefficient are generally high for scale whose length is only 10 items, and all values are large enough to indicate that each TOSRA scale had quite good internal consistency reliability at each level" (Fraser, 1981, p. 4, see below). Discriminant validity between scales was measured at 0.10 to 0.59 with a mean of 0.33, indicating that each scale measured a unique attitude not measured by the other six scales.

Table 4.3 Reliability and validity values for TOSRA instrument, from Fraser, 1981

	Mean in Year				Standard deviation in Year				α Reliability in Year				Test-retest reliability[a]	Mean correlation with other scales
Scale	7	8	9	10	7	8	9	10	7	8	9	10		
Social Implications of Science	35.7	34.2	35.9	37.3	5.7	6.2	4.9	5.2	0.81	0.82	0.75	0.82	0.76	0.39
Normality of Scientists	35.6	34.3	35.8	36.3	5.2	5.1	4.9	4.9	0.72	0.70	0.72	0.78	0.69	0.27
Attitude to Inquiry	40.5	39.3	38.2	35.9	5.8	6.2	5.9	6.7	0.81	0.82	0.81	0.86	0.79	0.13
Adoption of Scientific Attitudes	38.0	37.2	37.9	38.4	4.5	4.5	4.5	4.2	0.66	0.64	0.69	0.67	0.75	0.33
Enjoyment of Science Lessons	32.8	29.7	31.2	33.5	9.5	9.6	8.9	8.6	0.93	0.92	0.92	0.93	0.78	0.39
Leisure Interest in Science	27.5	24.7	24.9	26.9	8.6	8.3	8.0	8.4	0.88	0.85	0.87	0.89	0.82	0.39
Career Interest in Science	28.2	26.0	26.5	28.8	8.2	8.2	7.8	8.4	0.90	0.88	0.88	0.91	0.84	0.40
Mean of nine scales	34.0	32.2	32.9	33.9	6.8	6.9	6.4	6.6	0.82	0.80	0.81	0.84	0.78	0.33

Each scale contains 10 items scored from 1 to 5 so that the minimum and maximum score possible on each scale is 10 and 50 respectively.

The sample sizes at different levels ranged from 324 to 340.

a Test-retest coefficients were estimated for a sub-sample of 238 students from Years 8 and 9, drawn from the original sample.

Each statement in the TOSRA requires students to express their degree of agreement or disagreement with each statement on a five point Likert scale. Responses are Strongly Agree (SA), Agree (A), Not sure (N), Disagree (D), and Strongly disagree (SD). Scoring involves assigning values of 5, 4, 3, 2, 1 for the responses SA, A, N, D, SD for items that are positive (+). For items that are negative (-), values of 1, 2, 3, 4, and 5 are assigned for the responses SA, A, N, D, and SD (Fraser, 1981, p. 10, see below).

Table 4.4 Scale allocation and scoring for each item, from Fraser, 1981

S Social Implications of Science	N Normality of Scientists	I Attitude to Scientific Inquiry	A Adoption of Scientific Attitudes	E Enjoyment of Science Lessons	L Leisure Interest in Science	C Career Interest in Science
1 (+)	2 (–)	3 (+)	4 (+)	5 (+)	6 (+)	7 (–)
8 (–)	9 (+)	10 (–)	11 (–)	12 (–)	13 (–)	14 (+)
15 (+)	16 (–)	17 (+)	18 (+)	19 (+)	20 (+)	21 (–)
22 (–)	23 (+)	24 (–)	25 (–)	26 (–)	27 (–)	28 (+)
29 (+)	30 (–)	31 (+)	32 (+)	33 (+)	34 (+)	35 (–)
36 (–)	37 (+)	38 (–)	39 (–)	40 (–)	41 (–)	42 (+)
43 (+)	44 (–)	45 (+)	46 (+)	47 (+)	48 (+)	49 (–)
50 (–)	51 (+)	52 (–)	53 (–)	54 (–)	55 (–)	56 (+)
57 (+)	58 (–)	59 (+)	60 (+)	61 (+)	62 (+)	63 (–)
64 (–)	65 (+)	66 (–)	67 (–)	68 (–)	69 (–)	70 (+)

For positive items (+), responses SA, A, N, D, SD are scored 5, 4, 3, 2, 1, respectively. For negative items (–), responses SA, A, N, D, SD, are scored 1, 2, 3, 4, 5, respectively. Omitted or invalid responses are scored 3.

The maximum score per student on each subscale is 50.0 points. Scoring involves transcribing responses from letter values to numeric values and then summing results per subscale (see Appendix B). Scores are then averaged across subscales for a total TOSRA score per student. TOSRA was administered three times during the year, so for each student there are three mean scores.

4.5 Surveys

The TOSRA test allowed for a large set of data to be analyzed across grade levels and across genders. Findings were supported by qualitative data that was collected from girls who self-selected to participate in the science club for girls. To obtain qualitative data in support of the hypotheses, a combination of surveys and interviews were administered (see Appendices C and D). All students who self-selected to participate in the science club for girls were given a survey at the beginning, middle, and end of the year (see Appendix C). Survey questions addressed the level of impact that the science club had on girls' attitudes toward science. The questions also measured the impact of other variables that impact attitude, such as parents, classroom environment, and media. Surveys provided supporting evidence that is used in conjunction with the TOSRA to determine if there were any specific factors influencing attitudes toward science. Survey data was analyzed using cluster analysis and performed by the researcher and the teachers involved in the intervention.

4.6 Interviews

Exit interview questions were created based on pre-survey responses (see Appendix D). An interview question set modeled after the surveys was implemented. It addressed issues such as why students became involved in the club, what they learned, what influenced how they learned science, and many other related questions. A twenty-one question interview took place by telephone at the end of the school year and lasted no more than a half hour for each participant. Interviews were recorded and then transcribed. Cluster analysis within each free response question was used, with teachers and the researcher sorting responses.

CHAPTER 5

RESULTS

5.1 Overview of Results

Each data collection instrument is presented separately in the sections that follow with a brief summary of results preceding each section. We first explore the quantitative TOSRA data and then turn to the qualitative data collected through surveys and interviews. A more in-depth discussion of the results and integration across methodologies and corresponding instruments appears in Chapter 6, Discussion.

5.2 TOSRA Results

The Test of Science Related Attitudes (TOSRA) was selected as a tool to measure attitudes toward science of students in grades seven and eight because of its reliability and ability to measure multiple subscales involving attitudes toward science. The TOSRA was implemented at the beginning, middle, and end of the school year. We will first look at the overall results of the TOSRA test and will then turn to analysis of each subscale within the test.

Data were analyzed by analysis of variance as a mixed model with repeated measures using the mixed procedure of SAS (2001) with the repeated statement for assessment of the serial treatment and treatment by time interaction effects. The repeated statement used time as the variable with the interaction of student, club, gender, and grade as the subject. The variables in the model statement included gender, grade, club, time, and all two and three-way interactions between these variables. Least squares means, appropriate standard errors, and treatment effects at specific time points for repeated measures analysis were generated using the LSMeans statement in conjunction with the pdiff option (SAS, 2001). All reported means are the adjusted least squares means ± standard error of the mean.

Statistical power varied from 20% to 88% depending on comparisons studied (Cohen, 1988). In general, with an approximate standard deviation of 6 and wanting to detect a difference of 3 points on the TOSRA scale, in order to have 80% power there needed to be 64 students per comparison. Some comparisons had $\beta = .8$ or greater. However, other comparisons had lower power when trying to detect a difference of three units. In order to achieve 80% power, based on the number of observations per comparison, detectable differences ranged from 2.69 to 7.15.

The TOSRA was administered at the beginning, middle, and end of the school year to all students in grades 7 and 8. Based on prior research that utilized the TOSRA instrument, it was expected that when results were analyzed, student attitudes toward science in both grade levels would decrease over time. In analyzing the data, we find that the overall scores of students in grades 7 and 8 combined dropped from the beginning of the year to the end, with the lowest scores recorded at mid year. This change in scores was statistically significant ($P=.02$). Attitudes toward science in grades 7 and 8 decreased during the course of the school year. However, when we separate out the data and analyze each grade level individually, we find that grade seven attitudes showed a slight increase over time. Grade eight students began quite high and dropped dramatically by the middle of the year.

TOSRA data also was compared between girls who self-selected to participate in the science club and girls who chose not to participate in grades 7 and 8. It was expected that girls who self-selected to participate in the science club would have higher attitudes toward science than those who chose not to participate. It was also expected that this trend would be observable at beginning, middle and end of the year. There was not a statistically significant difference between those who chose to participate in the intervention and those who chose to participate in grades 7 and 8. There was no effect of the intervention by grade by time (P=0.25).

Next, TOSRA data was analyzed for girls who self-selected to participate in the science club for girls. It was expected that attitudes toward science of girls who self-selected to participate in the science club would remain the same or increase during the course of the school year. There was no effect of the intervention on scores over time (P = 0.86).

TOSRA data was also compared between students in grade 7 and grade 8. It was expected that there would be a greater negative total change in attitude for students in grade 7 than in grade 8. Indeed, this was not the case. Scores for students in grade 8 changed more dramatically during the course of the school year than scores for students in grade 7. The grade by time effect was statistically significant (P = 0.05), but the results were the opposite of what was expected (grade 8 showed more change than grade 7).

When looking at the seven subscales within the TOSRA, some statistically significant changes were observed. Within the Normality of Scientists scale, there was an effect of club by grade by time (see Figure 5.9). Grade seven scores for girls not in the club were higher at both midyear and end of the year than scores for girls in the club. This indicates that attitudes toward Normality of Scientists within grade seven girls were lower as the year progressed for girls participating in the science club intervention program than for girls not participating in the program. However, even though those in the club had lower scores, the career/role modeling activities during the second half of the year appear to have had a positive effect on the Normality of Scientists scores. Those in the club dropped to the lowest scores at midyear, after the hands-on activities, and then gained ground by the end of the year, after the career/role modeling activities. Further study would be needed to figure out what exactly caused the rise in scores, but it is plausible that the career/role modeling activities contributed to girls' positive feelings about Normality of Scientists.

Grade eight scores showed a different result; those girls in the club had higher attitudes toward Normality of Scientists as the year progressed than girls not in the club. The grade eight intervention for the first half of the year was career/role model activities, followed by hands-on activities during the second half of the year. Scores rose from beginning to middle of the year and then rose even more sharply in the second half of the year. Since there was a greater increase in attitudinal scores regarding Normality of Scientists for eighth grade girls in the club during the second half of the year, we can infer that the hands-on activities were more positively received than the career/role modeling activities. Both types of intervention appear to have impacted the scores as evidenced by the gradual increase over time. When we look at the grade seven and grade eight results comparatively, we can infer that the club had an effect on attitudes toward Normality of Scientists for both grade levels. However, when comparing within grade seven girls, we see that the club led to lower scores than no club.

We can then explore the data for Normality of Scientists including boys as well as girls, and we find that there was also an effect of club by grade by time when including the boys' data (see Figure 5.11). Including the boys' data did not cause any shifts in trends. Grade seven scores for those in the club showed a gradual decrease just as they had when looking at data for girls only, and scores for grade eight in the club showed an increase over time as they had in the data including only girls. These shifts over time were more pronounced when looking at the girls' data exclusively, most likely due to the smaller sample size.

Another subscale that saw differences over time was Enjoyment of Science Lessons (see Figure 5.21). There was an effect of grade by time between grades seven and eight. Grade seven scores for attitudes toward Enjoyment of Science Lessons increased over time, while grade eight scores decreased between the beginning and middle of the year and then increased slightly by the end of the year. Grade eight scores ended at a lower point than the beginning of the year, despite the slight increase between middle and end of the year. We can see, then, that grade seven students had increasingly positive feelings toward science lessons as the year progressed. Grade eight students had the least positive feelings toward science lessons at the middle of the year and also had less positive feelings at the end of the year than at the beginning.

These results related to Enjoyment of Science Lessons could be due to the influence of the classroom environment on student attitudes. Grade eight is a "high stakes" year for students in science, since they are preparing for the standardized test that is given at the end of the year. Grades on tests and lab activities are more critical for eighth graders than seventh graders, because they indicate preparedness for the standardized testing. Student responses to survey questions about why they liked or did not like certain subjects can also inform our conclusions about what impacted these students. Content that was too hard and mean teachers were two reasons that students disliked certain subjects throughout the year. And when asked to list negative science experiences, more eighth graders than seventh graders listed bad grades on tests and mean teachers on their surveys, which could help to explain why their enjoyment of science decreased during the year while seventh grade enjoyment increased.

The Leisure Interest in Science subscale also saw grade level differences over time (see Figure 5.24). Grade seven attitudes toward Leisure Interest in Science increased throughout the year. The same pattern for grade eight emerged that was seen in the Enjoyment of Science Lessons subscale. Grade eight scores decreased between the beginning and middle of the year and then increased by the end of the year, with a final score lower than the initial score for the year. Again, there is a similarity between these two subscales. We see that grade seven students had increasingly positive associations toward Leisure Interest in Science, while the grade eight students had increasingly negative associations toward Leisure Interest in Science between the beginning and middle of the year. Grade eight student scores for Enjoyment of Science Lessons rebounded slightly by the end of the year, but their final scores were lower than the beginning scores.

Exploring each subscale within the TOSRA data allows us to see more detail about what influences student attitudes toward science. Only three subscales showed statistically significant differences over time. The first one that was significant over time when considering club and grade, Normality of Scientists, did not show the same results as the overall TOSRA data (see Figure 5.5). Overall TOSRA data did not show a club by grade by time effect as did the Normality of Scientists subscale. However, the results found in the two subscales Enjoyment of Science Lessons and Leisure Interest in Science corroborate results from overall TOSRA scores over time for students in grade seven and grade eight (see Figure 5.3). In these two subscales and in overall TOSRA data, there were two patterns that emerged. For grade seven students, scores in these three analyses increased from beginning to middle to end of the year. For grade eight students, scores began high, dropped to a low at midyear, and then rebounded to end at a point lower than the initial scores.

We will now look at the results from each statistical test involving the TOSRA data as a whole and for each of the seven subscales over time. A more in-depth analysis appears in Chapter 6, Discussion.

5.2.1 TOSRA Scores Over Time

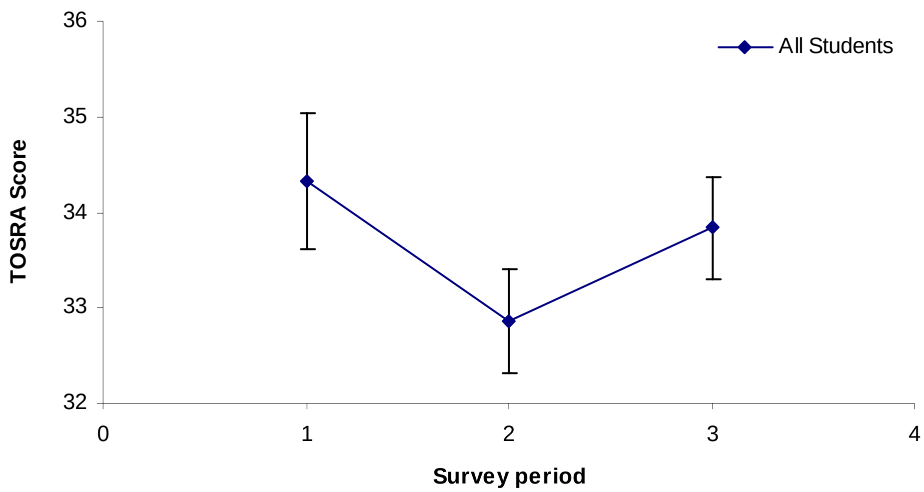

Figure 5.1 TOSRA scores over time[1,2] for seventh and eighth grade students (n=161) who did and did not participate in a science club intervention program.

[1] Error bars represent standard error of the mean
[2] Time effect, $P = 0.02$

TOSRA scores over time for all students in grades seven and eight showed a statistically significant (P = 0.02) difference between the beginning of the year and the end of the year. Scores had a value of 34.3 at the beginning of the year and then dropped to a low of 32.9 at midyear. By the end of the year, the overall TOSRA scores increased to 33.8 but were significantly lower than the scores at the beginning of the year.

5.2.2 TOSRA Scores Over Time By Intervention

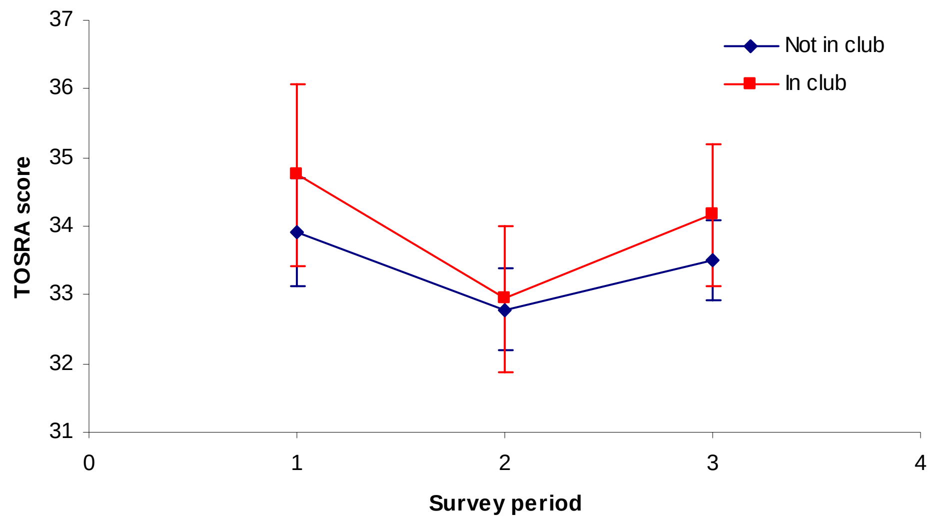

Figure 5.2 TOSRA scores over time[1,2] for students that participated (n=46) or did not participate (n=115) in a science club intervention program

[1] Error bars represent standard error of the mean
[2] No effect of club (*P* = 0.86)

TOSRA scores over time for students that participated in the science club intervention program were not statistically different from scores for students who did not participate in the club. Although the average scores were higher at each measurement point, there was not a significant difference in the scores over time (P = 0.86).

5.2.3 TOSRA Scores Over Time By Grade Level

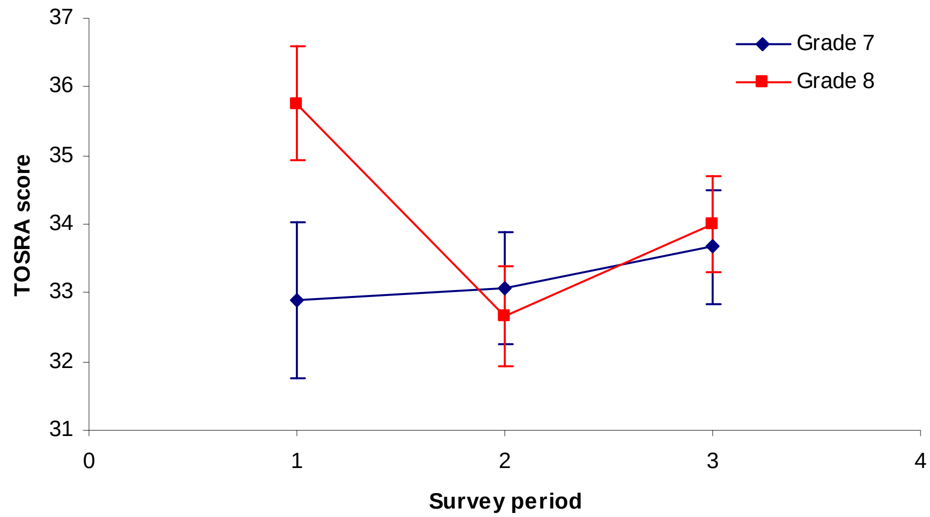

Figure 5.3 TOSRA scores over time[1,2] for students in grade seven (n=82) and grade eight (n=79)

[1] Error bars represent standard error of the mean
[2] Grade by time effect *P* = .05

TOSRA scores for students in grade seven and eight were significantly different over time. The grade by time effect for students in grades seven and eight was significant (P = .05). Students in grade seven showed an increase in scores between the beginning (32.9) and middle (33.1) of the school year. This trend continued to the end of the school year, with overall grade seven scores increasing from 32.9 to 33.7. Grade eight scores started high (35.8) and then dropped to a yearlong low (32.7) at midyear. Scores increased between middle and end of the school year for grade eight, ending at a score of 34.0, which is lower than the beginning of the year yet higher than the midyear score.

5.2.4 TOSRA Scores Over Time By Gender

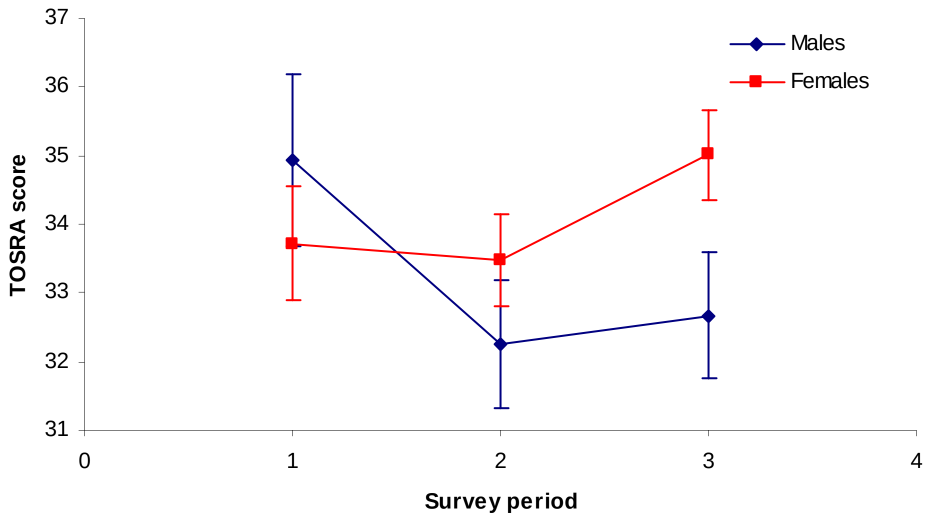

Figure 5.4 TOSRA scores over time[1,2] for male (n=76) students and female (n=85) students in grades seven and eight

[1] Error bars represent standard error of the mean
[2] Gender by time trend (*P* = 0.11)

TOSRA scores over time for male and female students were not statistically different. Although there was a trend in gender affecting scores over time, the differences were not significant (P = 0.11). Male scores started out higher (34.9) than female (33.7) scores, dropped to a midyear low score of 32.2, and then increased slightly between midyear and end of the year (32.7). Female scores dropped from the beginning of the year (33.7) to the middle (33.5) but then increased between midyear and end of the year (35.0).

5.2.5 TOSRA Scores Over Time By Club and Grade

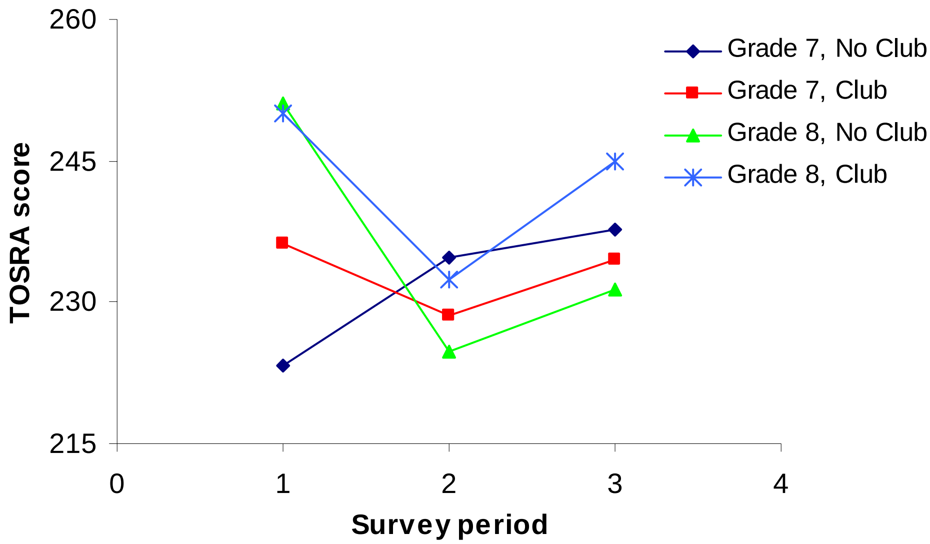

Figure 5.5 TOSRA scores over time[1] for students in grade seven (n=82) and grade eight (n=79) and for students that participated (n=46) or did not participate (n=115) in a science club intervention program[2]

[1] No effect of club by grade by time $P = 0.66$
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

TOSRA scores over time for students in grade seven and grade eight that participated in the science club intervention were not statistically different from scores of students who did not participate in the intervention (P = 0.66).

5.2.6 TOSRA Scores Over Time By Club and Grade for Girls Only

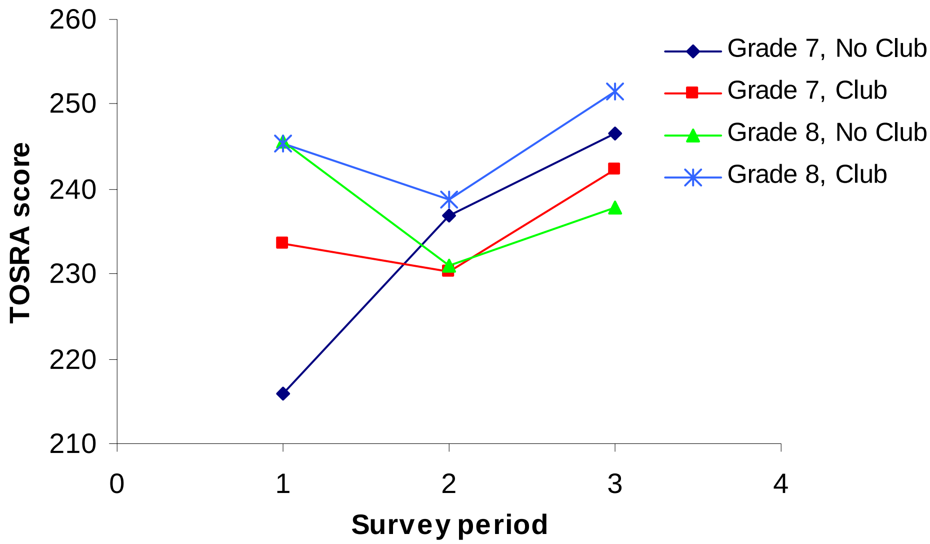

Figure 5.6 TOSRA scores over time[1] for girls in grade seven (n=44) that did (n=17) and did not participate (n=27) and girls in grade eight (n=41) that did (n=29) and did not participate (n=12) in a science club intervention program[2]

[1] No effect of club by grade by time *P* = 0.25
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

TOSRA scores over time for girls in grade seven who did and did not participate were not statistically different from scores from girls in grade eight who did and did not participate in the intervention (P = 0.25).

5.2.7 TOSRA Scores for Subscale S (Social Implications of Science)

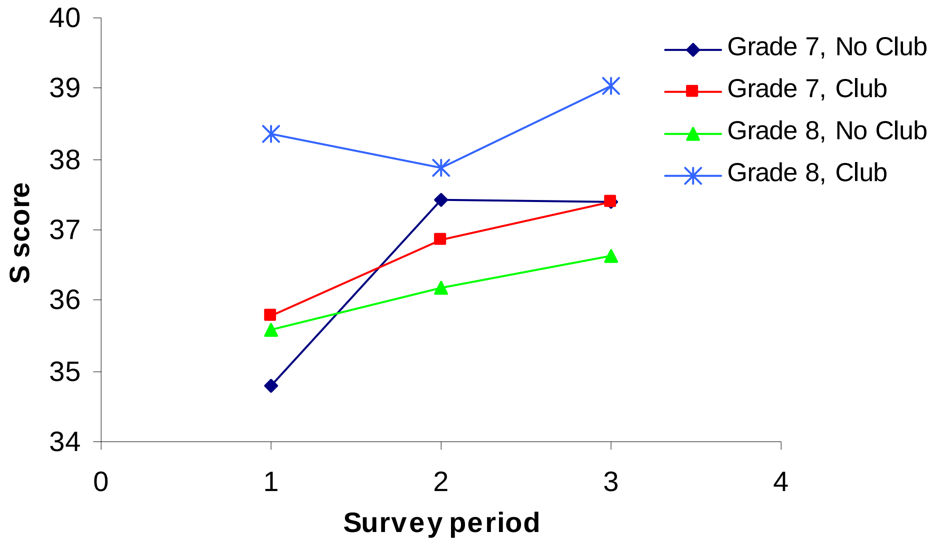

Figure 5.7 Social Implications of Science (S) subscale scores over time[1] for girls only (n=85) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, $P = 0.82$, largest SE = 2.03
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Social Implications of Science (S) scores over time for girls who did and did not participate in the science club intervention program did not show a statistically significant (P = 0.82) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between girls who did and did not participate in the intervention.

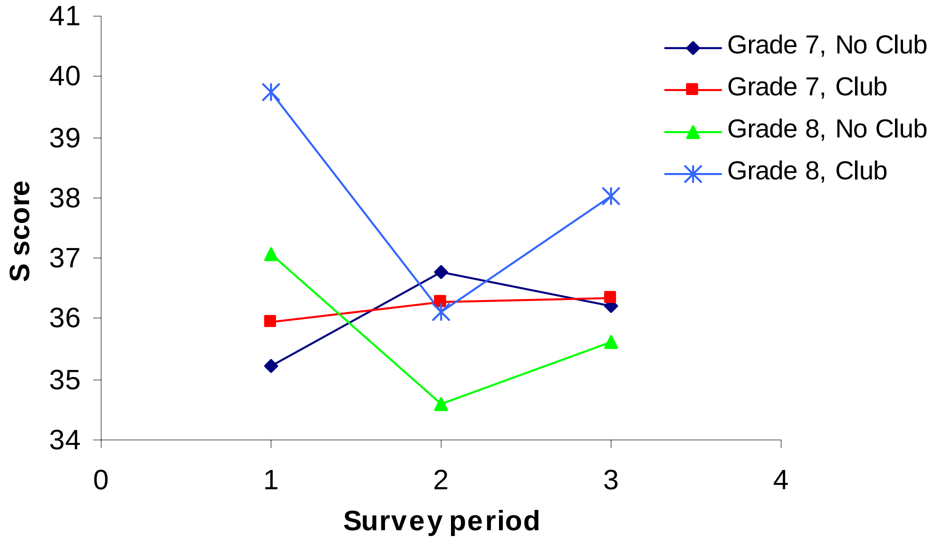

Figure 5.8 Social Implications of Science (S) subscale scores over time[1] for all students (n=161) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, *P* = 0.88, largest SE = 2.69
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Social Implications of Science (S) scores over time for all students did not show a statistically significant (P = 0.88) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between students (both boys and girls) who did and did not participate in the intervention.

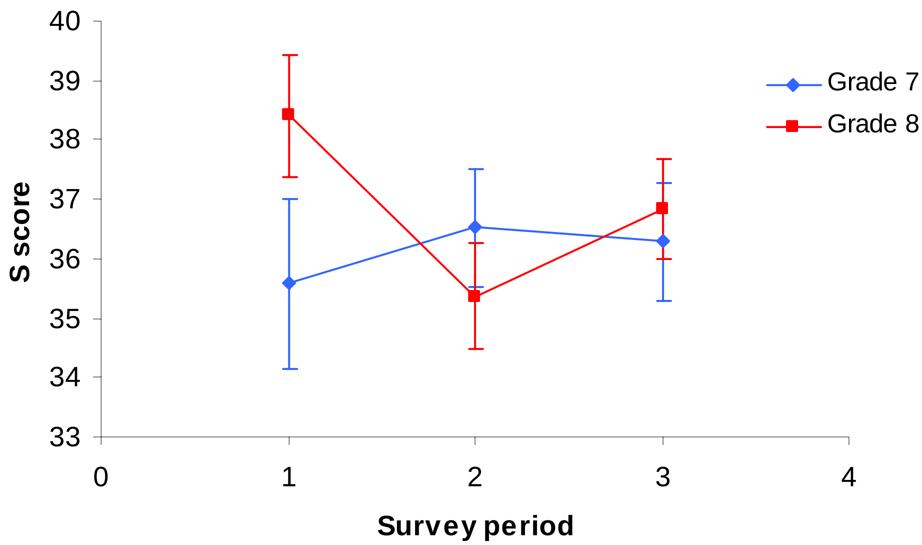

Figure 5.9 Social Implications of Science (S) subscale scores over time[1,2] for all students in grade seven (n=82) and grade eight (n=79)

[1] Error bars represent standard error of the mean
[2] Trend of grade by time, $P = 0.07$

Social Implications of Science (S) scores over time for all students in grade seven and grade eight did not show a statistically significant (P = 0.07) difference between the beginning of the year and the end of the year by grade level. However, there was a trend of grade by time.

5.2.8 TOSRA Scores for Subscale N

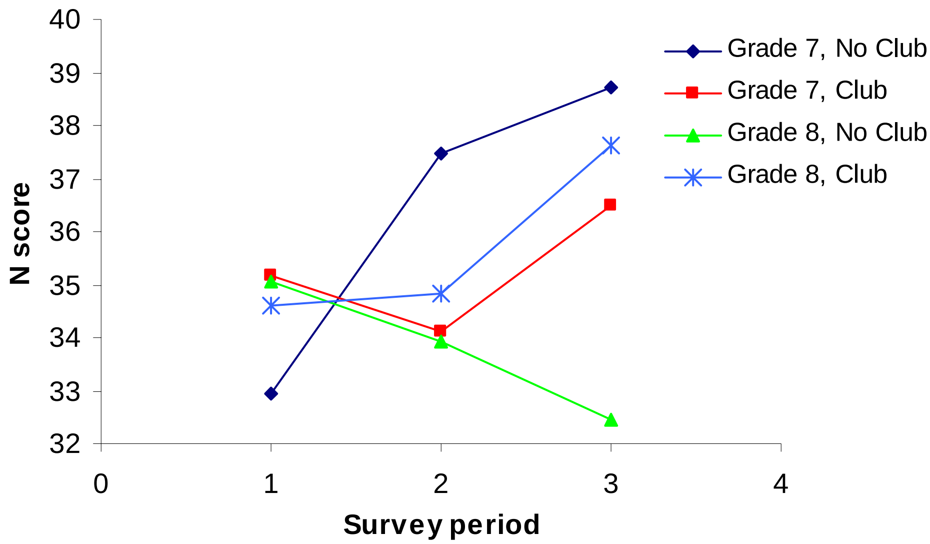

Figure 5.10 Normality of Scientists (N) subscale scores over time[1] for girls only (n=85) who did and did not participate in a science club intervention program[2]

[1] Effect of club by grade by time, *P* = 0.004, largest SE = 1.69
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Normality of Scientists (N) scores over time for girls who did and did not participate in the science club intervention program showed a statistically significant (P = 0.004) difference between the beginning of the year and the end of the year. Grade seven scores for girls in the club declined from beginning of the year (35.2) to the middle (34.12) but then increased by the end of the year (36.5). Grade seven scores for girls not in the club increased from the beginning (33.0) to middle (37.5) to end (38.7) of the year. Grade seven scores for girls not in the club were higher at both midyear and end of the year than scores for girls in the club. Grade eight scores for girls in the club increased from the beginning (34.6) to middle (34.8) to end (37.6) of the year. Grade eight scores for girls not in the club decreased gradually throughout the year, from beginning (35.1) to middle (33.9) to end (32.5).

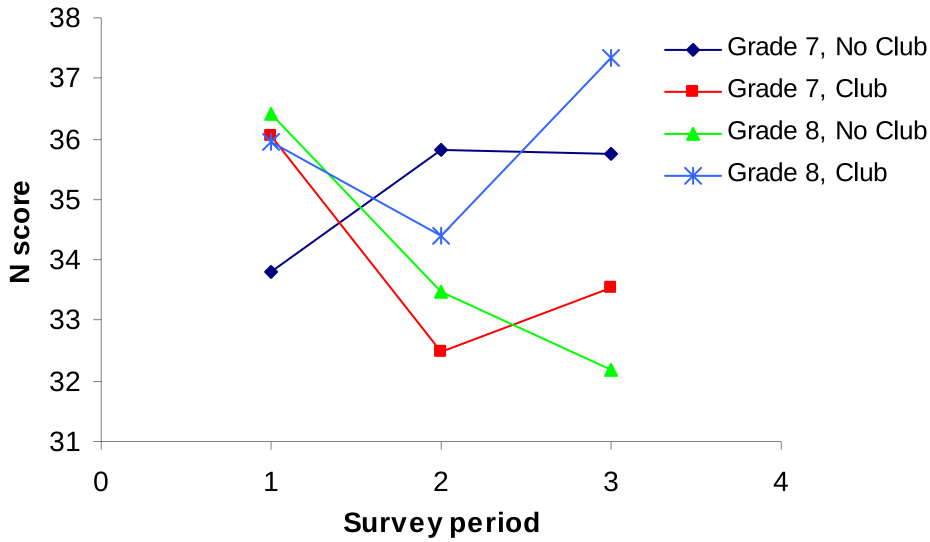

Figure 5.11 Normality of Scientists (N) subscale scores over time[1] for all students in grade 7 and grade 8 (n=161) who did and did not participate in a science club intervention program[2]

[1] Effect of club by grade by time, *P* = 0.025, largest SE = 2.34
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Normality of Scientists (N) scores over time for all students in grade 7 and grade 8 showed a statistically significant (P = 0.025) difference between the beginning of the year and the end of the year. Grade seven students in the club started out with a relatively high score (36.0) and then dropped to a low at midyear (32.5). By the end of the year, the grade seven scores had risen (33.5) but still ended at a point lower than the beginning of the year. Grade seven students not in the club showed a gradual increase from beginning (33.8) to middle (35.8) and then remained constant to the end (35.8) of the year. Grade eight students in the club had a relatively high beginning score (36.0), then dropped to a low (34.4) at midyear and ended (37.3) at a point higher than the initial score. Grade eight students not in the club showed a decrease from beginning (36.4) to middle (33.5) to end (32.2) of the year.

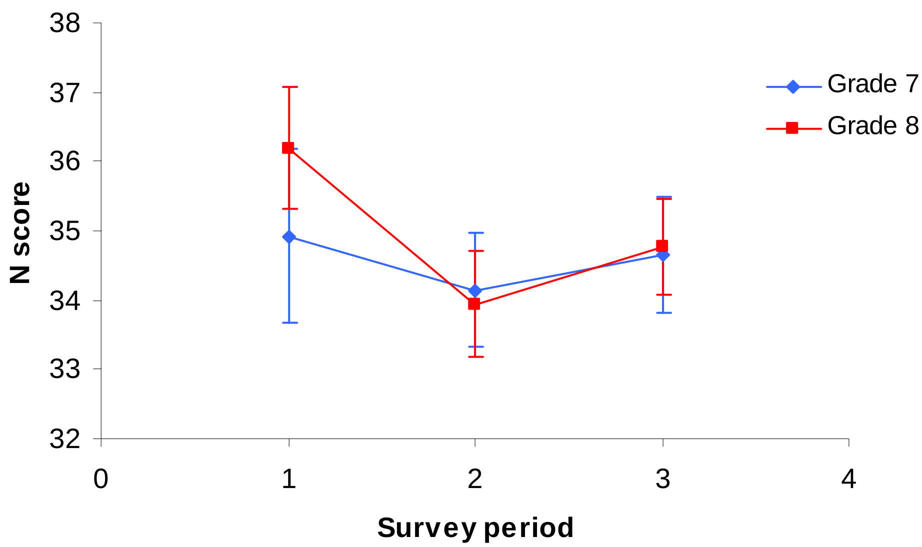

Figure 5.12 Normality of Scientists (N) subscale scores over time[1,2] for all students in grade seven (n=82) and grade eight (n=79)

[1] Error bars represent standard error of the mean
[2] No effect of grade by time, $P = 0.67$

Normality of Scientists (N) scores over time for all students in grade seven and grade eight did not show a statistically significant ($P = 0.67$) difference between the beginning of the year and the end of the year by grade level.

5.2.9 TOSRA Scores for Subscale I

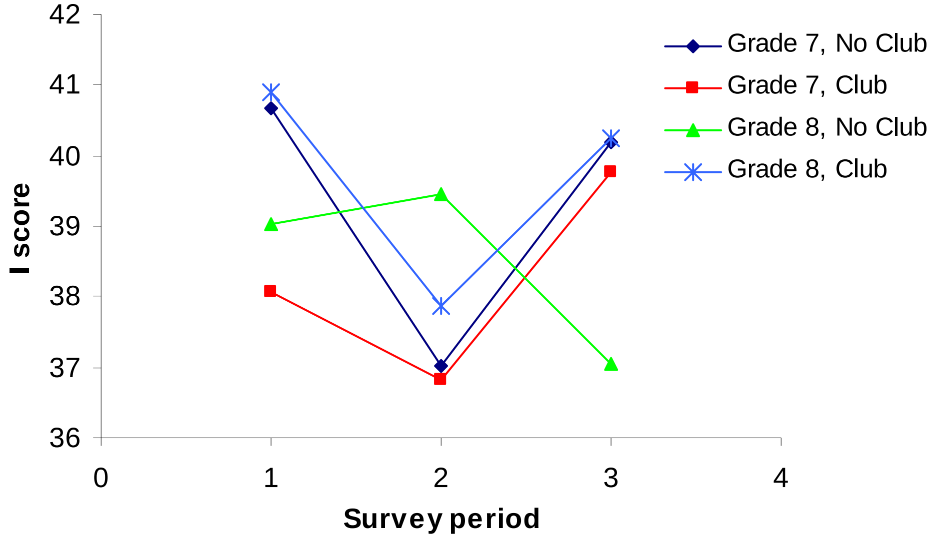

Figure 5.13 Attitude to Scientific Inquiry (I) subscale scores over time[1] for girls only (n=85) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, *P* = 0.21, largest SE = 2.29
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Attitude to Scientific Inquiry (I) scores over time for girls who did and did not participate in the science club intervention program did not show a statistically significant (P = 0.21) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between girls who did and did not participate in the intervention.

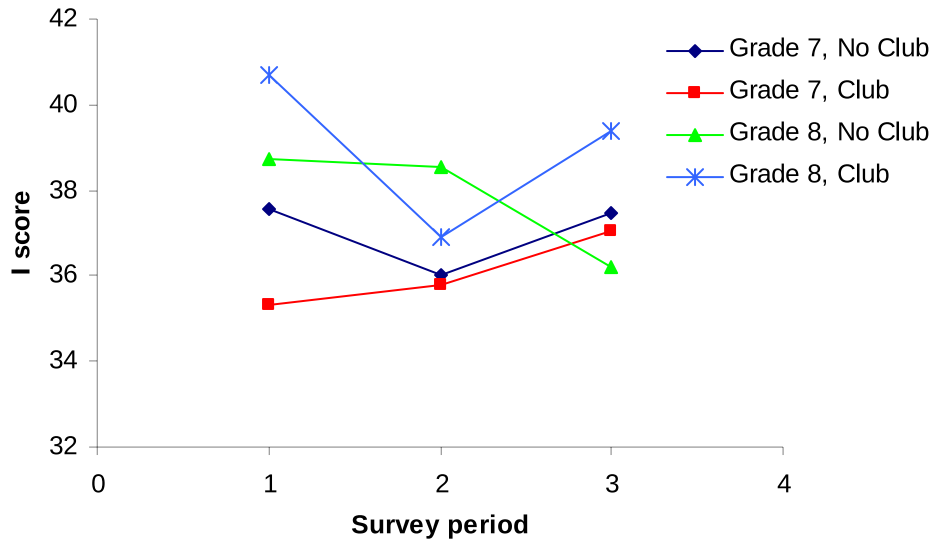

Figure 5.14 Attitude to Scientific Inquiry (I) subscale scores over time[1] for all students (n=161) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, *P* = 0.26, largest SE = 2.76
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Attitude to Scientific Inquiry (I) scores over time for all students did not show a statistically significant (P = 0.26) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between students (both boys and girls) who did and did not participate in the intervention.

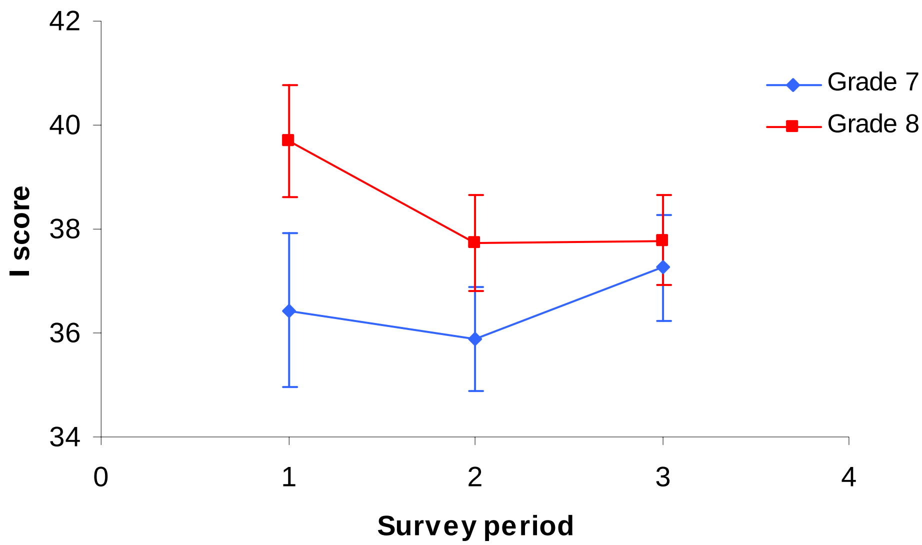

Figure 5.15 Attitude to Scientific Inquiry (I) subscale scores over time[1,2] for all students in grade seven (n=82) and grade eight (n=79)

[1] Error bars represent standard error of the mean
[2] No effect of grade by time, $P = 0.36$

Attitude to Scientific Inquiry (I) scores over time for all students in grade seven and grade eight did not show a statistically significant ($P = 0.36$) difference between the beginning of the year and the end of the year by grade level.

5.2.10 TOSRA Scores for Subscale A

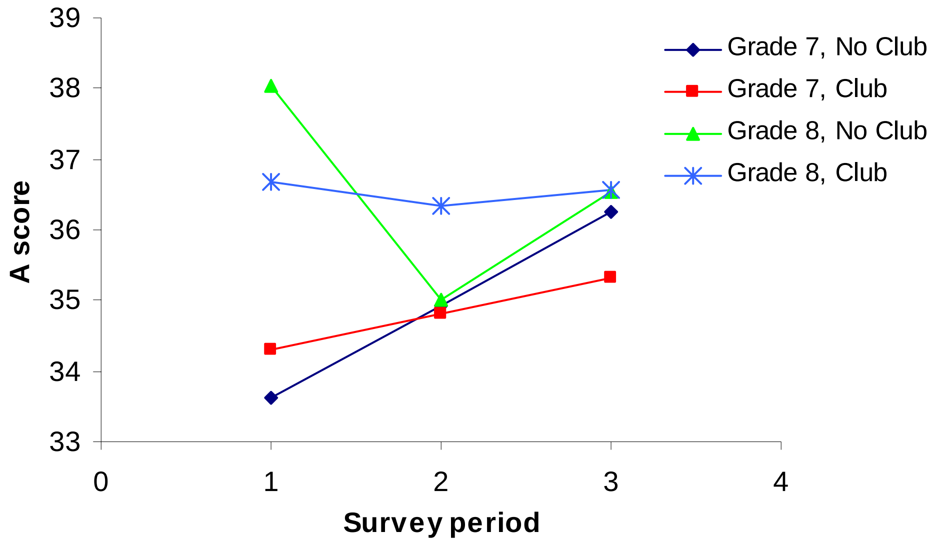

Figure 5.16 Adoption of Scientific Attitudes (A) subscale scores over time[1] for girls only (n=85) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, P = 0.71, largest SE = 1.81
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Adoption of Scientific Attitudes (A) scores over time for girls who did and did not participate in the science club intervention program did not show a statistically significant (P = 0.71) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between girls who did and did not participate in the intervention.

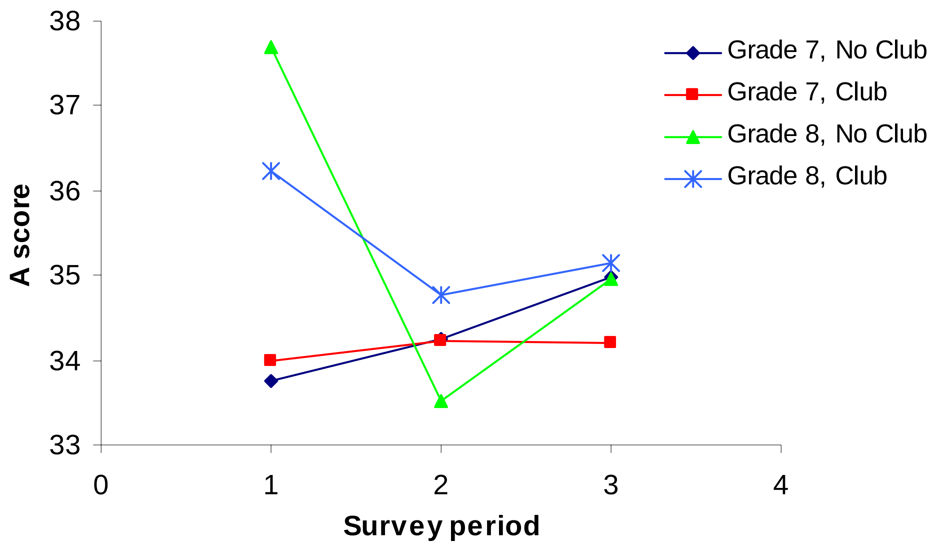

Figure 5.17 Adoption of Scientific Attitudes (A) subscale scores over time[1] for all students (n=161) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, P = 0.88, largest SE = 2.31
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Adoption of Scientific Attitudes (A) scores over time for all students did not show a statistically significant (P = 0.88) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between students (both boys and girls) who did and did not participate in the intervention.

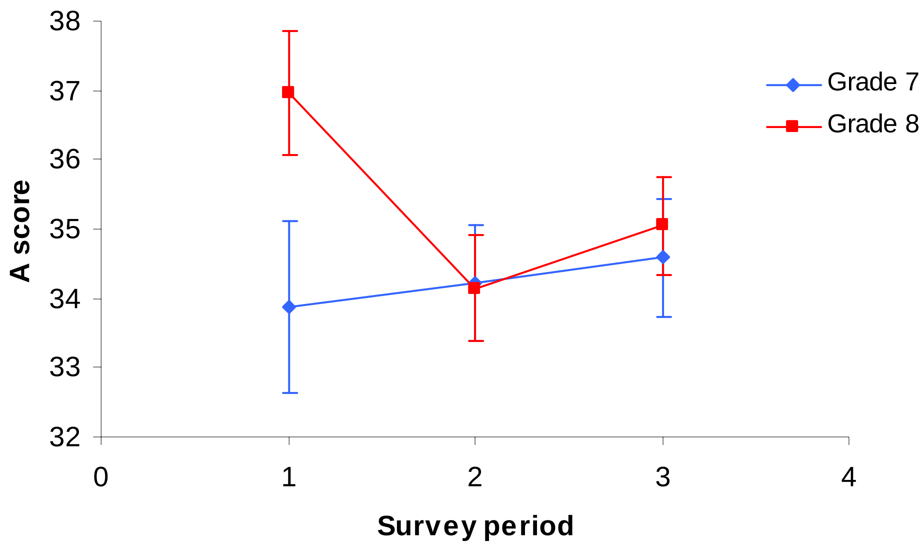

Figure 5.18 Adoption of Scientific Attitudes (A) subscale scores over time[1,2] for all students in grade seven (n=82) and grade eight (n=79)

[1] Error bars represent standard error of the mean
[2] No effect of grade by time, P = 0.13

Adoption of Scientific Attitudes (A) scores over time for all students in grade seven and grade eight did not show a statistically significant (P = 0.13) difference between the beginning of the year and the end of the year by grade level.

5.2.11 TOSRA Scores for Subscale E

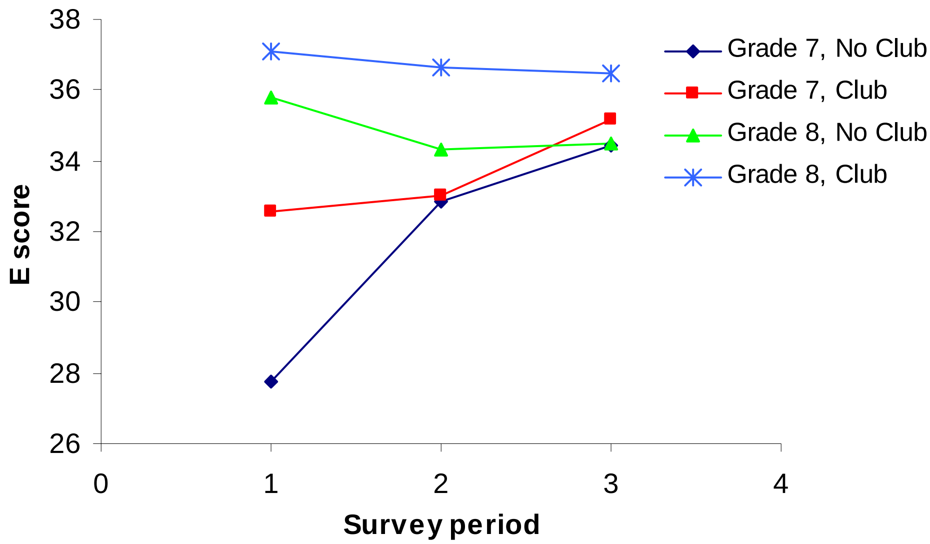

Figure 5.19 Enjoyment of Science Lessons (E) subscale scores over time[1] for girls only (n=85) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, *P* = 0.54, largest SE = 2.55
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Enjoyment of Science Lessons (E) scores over time for girls who did and did not participate in the science club intervention program did not show a statistically significant (P = 0.54) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between girls who did and did not participate in the intervention.

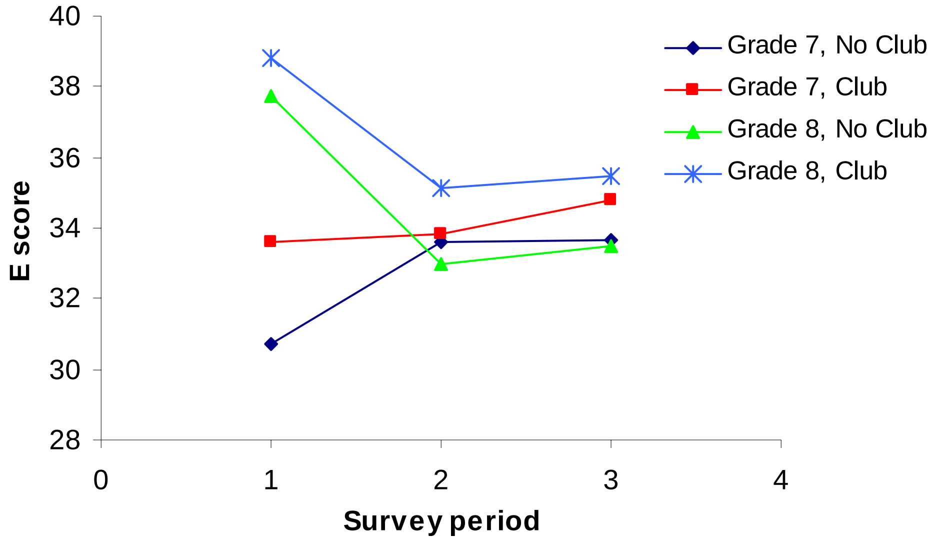

Figure 5.20 Enjoyment of Science Lessons (E) subscale scores over time[1] for all students (n=161) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, *P* = 0.91, largest SE = 3.25
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Enjoyment of Science Lessons (E) scores over time for all students did not show a statistically significant (P = 0.91) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between students (both boys and girls) who did and did not participate in the intervention.

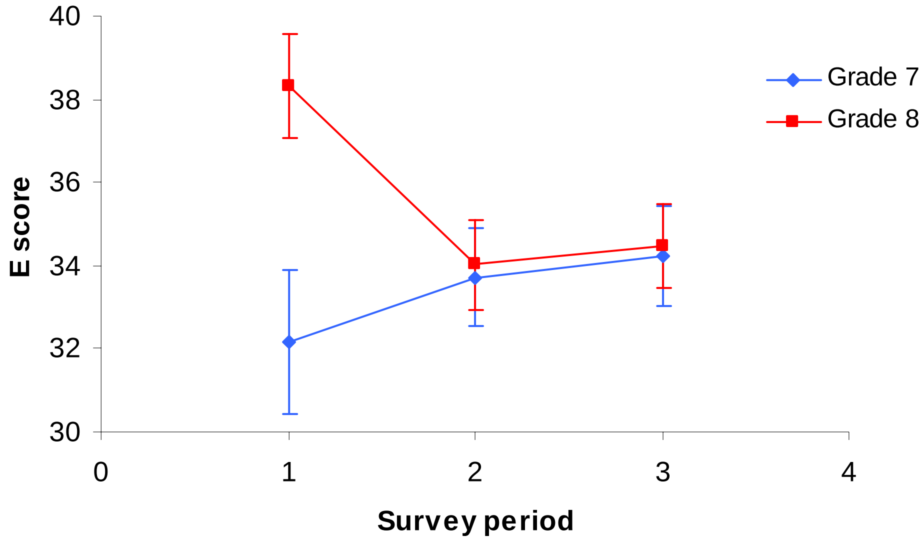

Figure 5.21 Enjoyment of Science Lessons (E) subscale scores over time[1,2] for all students in grade seven (n=82) and grade eight (n=79)

[1] Error bars represent standard error of the mean
[2] Effect of grade by time, $P = 0.0249$

Enjoyment of Science Lessons (E) scores over time for all students in grade seven and grade eight showed a statistically significant (P =0.0249) difference between the beginning of the year and the end of the year by grade level. Grade seven scores increased between beginning (32.2) to middle (33.7) to end (34.2) of the year. Grade eight scores decreased from beginning (38.3) to middle (34.0) of the year. These scores then increased slightly by end of the year (34.5) but ended at a point lower than the beginning of the year.

5.2.12 TOSRA Scores for Subscale L

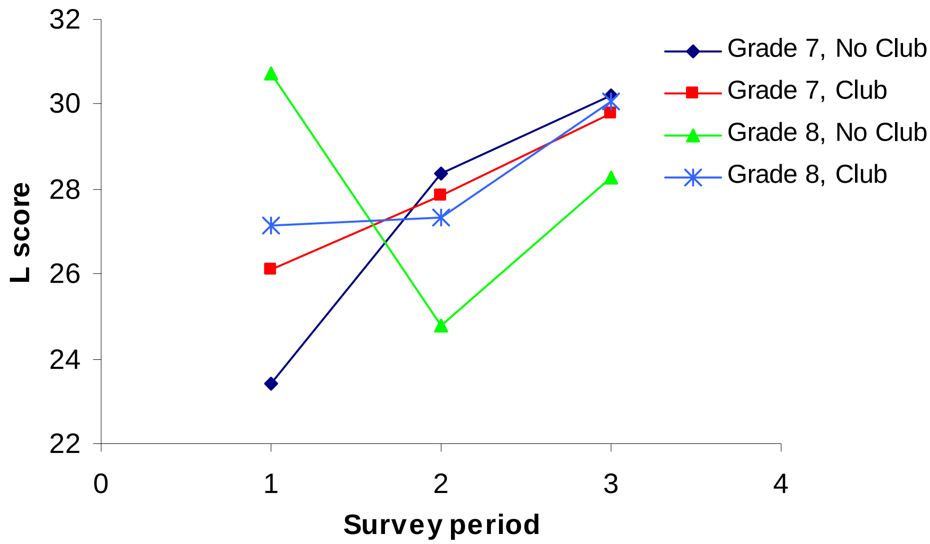

Figure 5.22 Leisure Interest in Science (L) subscale scores over time[1] for girls only (n=85) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, *P* = 0.25, largest SE = 2.89
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Leisure Interest in Science (L) scores over time for girls who did and did not participate in the science club intervention program did not show a statistically significant (P = 0.25) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between girls who did and did not participate in the intervention.

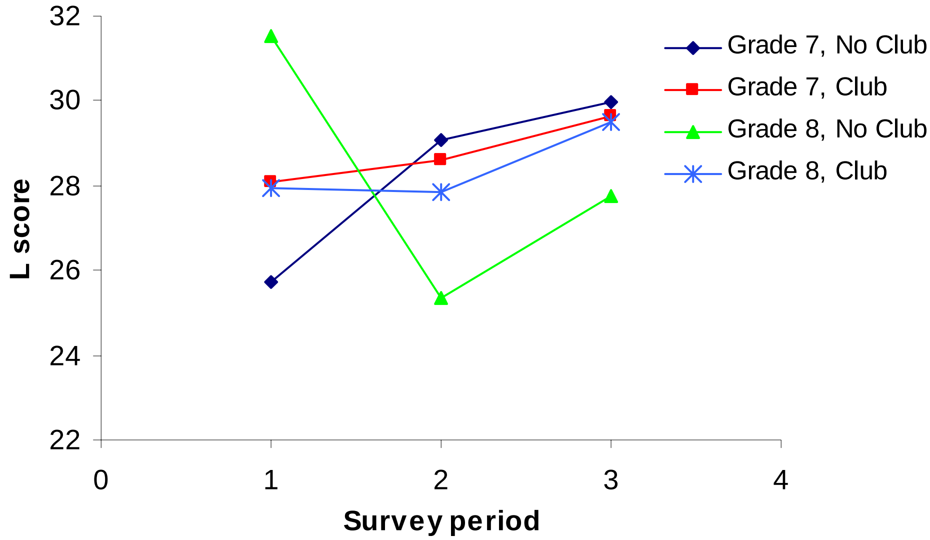

Figure 5.23 Leisure Interest in Science (L) subscale scores over time[1] for all students (n=161) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, P = 0.30, largest SE = 3.1
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Leisure Interest in Science (L) scores over time for all students did not show a statistically significant (P = 0.30) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between students (both boys and girls) who did and did not participate in the intervention.

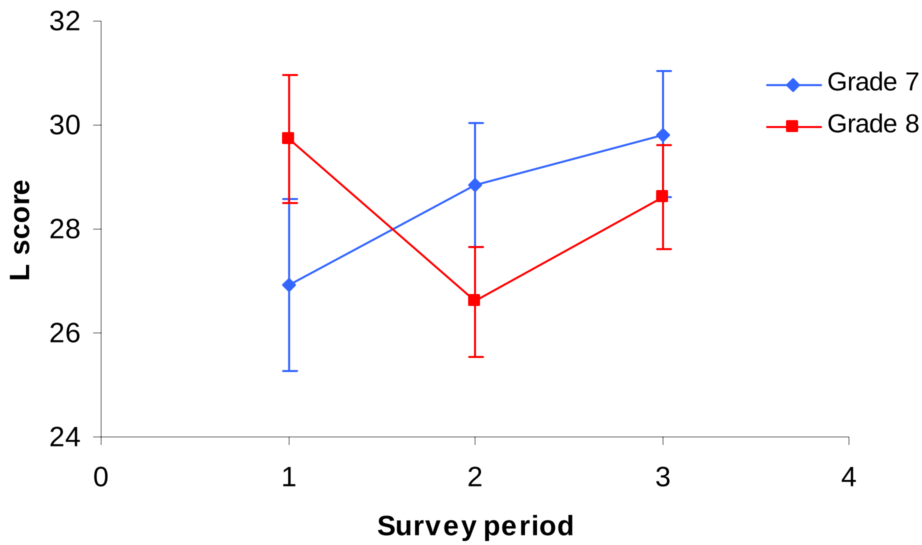

Figure 5.24 Leisure Interest in Science (L) subscale scores over time[1,2] for all students in grade seven (n=82) and grade eight (n=79)

[1] Error bars represent standard error of the mean
[2] Effect of grade by time, *P* = 0. 0356

Leisure Interest in Science (L) scores over time for all students in grade seven and grade eight showed a statistically significant (P =0.0356) difference between the beginning of the year and the end of the year by grade level. Grade seven scores increased between beginning (26.9) to middle (28.8) to end (29.8) of the year. Grade eight scores decreased from beginning (29.7) to middle (26.6) of the year. These scores then increased by the end of the year (28.6) but at a point lower than the beginning of the year.

5.2.13 TOSRA Scores for Subscale C

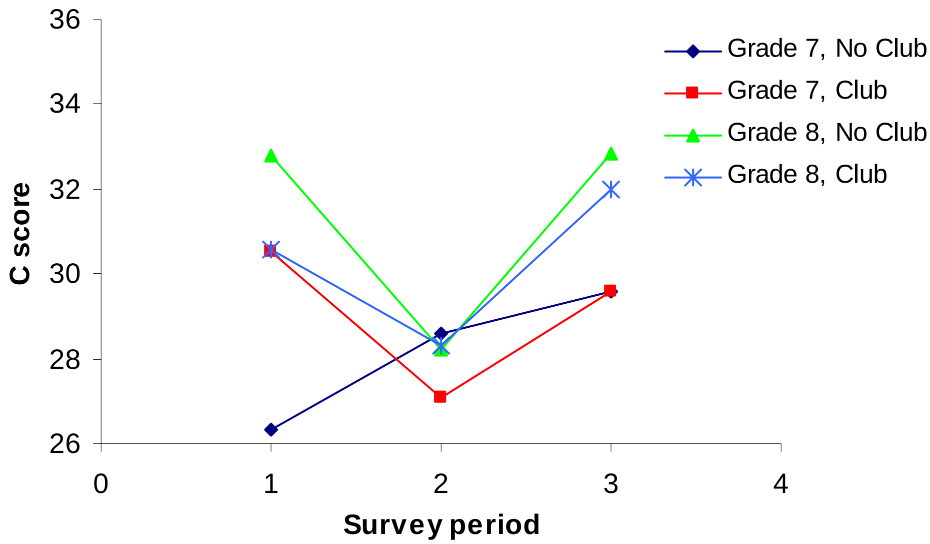

Figure 5.25 Career Interest in Science (C) subscale scores over time[1] for girls only (n=85) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, $P = 0.36$, largest SE = 2.94
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Career Interest in Science (C) scores over time for girls who did and did not participate in the science club intervention program did not show a statistically significant (P = 0.36) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between girls who did and did not participate in the intervention.

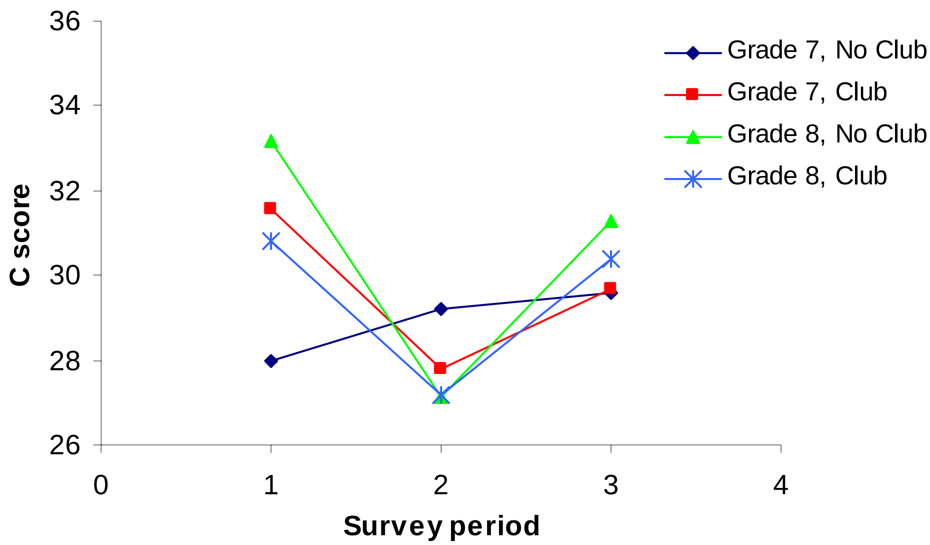

Figure 5.26 Career Interest in Science (C) subscale scores over time[1] for all students (n=161) who did and did not participate in a science club intervention program[2]

[1] No effect of club by grade by time, *P* = 0.50, largest SE = 3.37
[2] Grade 7 club format was hands-on and then role model; Grade 8 club format was role model and then hands-on

Career Interest in Science (C) scores over time for all students did not show a statistically significant (P = 0.50) difference between the beginning of the year and the end of the year. There were no significant differences between grade levels or between students (both boys and girls) who did and did not participate in the intervention.

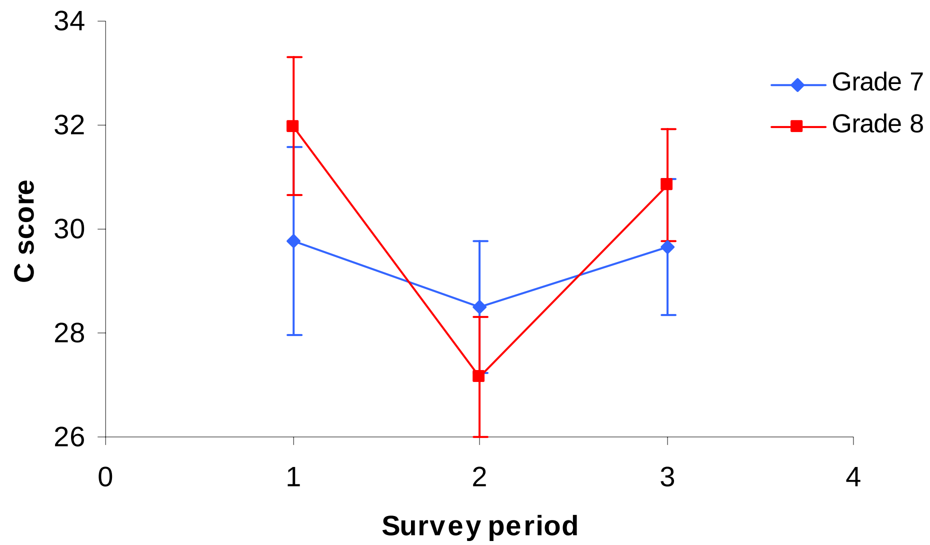

Figure 5.27 Career Interest in Science (C) subscale scores over time[1,2] for all students in grade seven (n=82) and grade eight (n=79)

[1] Error bars represent standard error of the mean
[2] Trend of grade by time, $P = 0.1033$

Career Interest in Science (C) scores over time for all students in grade seven and grade eight did not show a statistically significant (P = 0.1033) difference between the beginning of the year and the end of the year by grade level. However, there was a trend of grade by time.

5.3. Survey Results

The surveys provided insight into factors that influenced how girls learn science and what influences their attitudes. The most influential factors in girls learning were teachers, television, and newspapers/magazines. Attitudes were impacted by teachers, grades, and other school related factors. The surveys indicated that girls' impressions of themselves as scientists improved during the school year, and although this cannot be directly attributed to the intervention, it is possible that the female scientist guest speakers influenced the girls' impressions. We will now look at each instrument with its corresponding data. A full analysis of the data over time appears in Chapter 6, Discussion.

5.3.1 Pre-survey Data

The pre-survey instrument consisted of 21 questions that were a combination of free response and affirmative/negative response. Thirty-eight club members participated in the pre-survey, 19 seventh graders and 18 eighth graders. Pre-survey data was analyzed using cluster analysis for free response items and averages for affirmative/negative responses. This data was analyzed by the researcher and is presented below in table format followed by discussion of each result.

Table 5.1 Pre-survey response categories with number of responses

QUESTION	PRECATEGORIES	#
favorite subject	science	12
	math	4
	other inc art, French, English	22
least fav subject	math	23
	other inc gym English, Spanish	15
extracurricular activities	sports	32
	other inc band and chorus	4
	nothing	2
what do you do for fun	communicating with friends	26
	sports	4
	other inc reading, listening to music, being outside	8

Table 5.1 (Continued)

what career are you considering	teaching	7
	vet/doctor/science	9
	don't know and blank	8
	other inc hairdresser, lawyer, "rockette"	12
why did you join the club	science is fun	31
	to be with friends	3
	to learn something new	4
what do you want to learn in club	experiments	5
	about science	30
	no response	3
positive science experience	lab experiments	20
	at home science	4
	achievement related science	4
	outdoor science	6
negative science experience	achievement related science	15
	lab experiments	7
	other inc teacher and people that talk in class	2
	blank (no response)	6
	none	6
what is science	study of everything	7
	study of life	5
	study of the world	13
	life	3
	everything	3
what do scientists do	studies/tests things	13
	does experiments	11
	solves problems	6
	improves the world	5

5.3.1.1 Question 1: What is your favorite subject? Why?

Responses to this question were grouped into science, math and other. Twelve students listed science as their favorite subject, four listed math, and the other twenty-two students listed subjects including art, French, and English. For those who listed science, the follow up question of "Why" included "hands-on," "because it's fun," and "I like to do experiments."

5.3.1.2 Question 2: What is your least favorite subject? Why?

Responses were grouped into two categories: math and other. An overwhelming twenty-three students listed math as their least favorite subject for reasons including "it's very confusing and hard," "we always have tests," and "mean teacher." The other fifteen students listed a combination of subjects including gym, English, and Spanish.

5.3.1.3 Question 3: What extracurricular activities do you participate in (sports, music, drama club, student council, etc.)?

Responses were grouped into two categories: sports and other. Thirty-two members listed sports as an extracurricular activity, while the other six included chorus and band or listed nothing (two responses).

5.3.1.4 Question 4: What do you like to do for fun?

Responses were clustered into three categories: communicating with friends, sports, and solitary activities. Twenty-six students listed communicating with friends in various ways such as Internet messaging ("IM"), talking on the phone, and hanging out with friends. Four students listed sports as their fun activity, and the remaining eight student responses included reading, listening to music, and being outside.

5.3.1.5 Question 5: What kind of career are you considering?

Career responses were grouped into four categories: teaching, vet/doctor/science related, “don’t know,” and other. Seven students listed teaching as their career choice, and nine listed something science related including doctor and vet. Eight stated either “don’t know” or left it blank. The remaining twelve students listed careers such as journalism, hair dresser, lawyer, and “rockette.”

5.3.1.6 Question 6: Are you planning to attend college?

This question required a “yes” or “no” response. Thirty-seven students, 97%, answered yes, and one wrote in “maybe.”

5.3.1.7 Question 7: Why did you join the Tri-Sci Club?

Responses were grouped into three categories: science is fun, to be with friends, and to learn something new. Thirty-one students responded with something related to science being fun. These answers included “I like science and it’s fun to experiment” and “I did it last year and it was fun.” Three students joined to be with friends, and also two of those who said it was fun also included their friends in their answers. The remaining four students listed learning something new. These responses included, “I like science and I want to learn more” and “to learn something new.”

5.3.1.8 Question 8: What would you like to learn from being in this club?

Responses for this question were grouped into three categories: experiments, about science, and no response. Five students listed experiments, and thirty listed something about science such as “more about science” or “anything about science.” Three had no response.

5.3.1.9 Question 9: Please tell us about a positive experience you have had involving science.

Responses to this prompt were divided into four categories: lab experiments, at home science, achievement related science, and outdoor science. Twenty students listed a school-related lab experiment as a positive experience. These included “any experiment” and “making ice cream out of liquid nitrogen.” Four students listed an experience at home such as “trying to help my dad rebuild the car” and “turning my sister’s hair green.” Four students listed an achievement related positive experience. These included “good grades on tests” and “I won a pyramid marshmallow building contest.” Six students listed an outdoor science experience as positive including “looking at fossils and rocks outside” or “go[ing] outside and finding animals in the creek.”

5.3.1.10 Question 10: Please tell us about a negative experience you have had involving science.

Responses to the negative experience prompt were clustered into five categories: achievement related science, lab experiments, other, no response, and “none.” Fifteen responses involved something related to achievement, including “taking tests” and “failing tests.” Seven responses referred to a specific experiment such as “dissecting a frog” and “my kite that we made.” The two other responses were “7^{th} grade with Mr. Ott” and “people that don’t pay attention and talk.” There was a group of six students who wrote “none” indicating that they had not had a negative experience involving science. Six students had no response.

5.3.1.11 Questions 11-18 Responses to How Students Learn About Science

The following questions required yes/no responses. Percentages of affirmative responses are given for each question.

Question 11 Do you believe you are good at learning about science?

Thirty out of thirty-seven responses, 81%, believed they were good at learning about science. There was one no response.

Questions 12 through 18 compared various factors that help students learn about science. A summary chart of these influential factors appears below, followed by descriptions of each result.

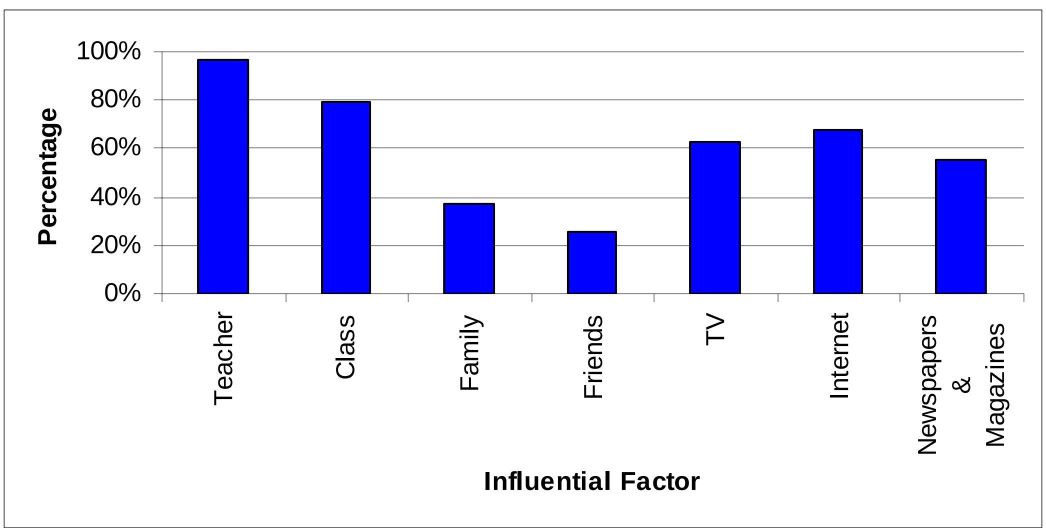

Figure 5.28 Percentage of students who responded affirmatively to questions of influential factors on the pre-survey

Question 12: Does your teacher help you learn about science?

Thirty-seven out of thirty-eight responses, 97%, responded affirmatively to their teachers helping them learn about science.

Question 13: Does your science class help you learn about science?

Thirty out of thirty-eight responses, 79%, responded affirmatively to science class helping them learn about science.

Question 14: Does your family help you learn about science?

Fourteen out of thirty-eight responses, 37%, responded affirmatively to family helping them learn about science.

Question 15: Do your friends help you learn about science?

Ten out of thirty-eight responses, 26%, responded affirmatively to friends helping them learn about science.

Question 16: Does TV help you learn about science?

Twenty-four out of thirty-eight responses, 63% responded affirmatively to TV helping them learn about science.

Question 17: Does the Internet help you learn about science?

Twenty-six out of thirty-eight responses, 68% responded affirmatively to the Internet helping them learn about science.

Question 18: Do newspapers or magazines help you learn about science?

Twenty-one out of thirty-eight responses, 55% responded affirmatively to newspapers or magazines helping them learn about science.

5.3.1.12 Question 19: What is science?

Responses to this question were clustered into five groups: study of everything, study of life, study of the world, life, and everything. Seven students listed the study of everything, while five students listed the study of life. Thirteen students listed study of the world or “everything around you.” Three students listed life, and three students listed everything.

5.3.1.13 Question 20: Please describe what a scientist does.

Responses were grouped into four categories to describe what a scientist does: studies/tests things, does experiments, solves problems, improves the world. Thirteen students believed that scientists study or test things. Responses included “a scientist studies our world” and “studies theories and answers questions.” Eleven students mentioned scientists doing experiments such as “experiments for answers in life” and “does experiments to find conclusions.” Another group of six students wrote about problem solving including “solve problems” and “solve unsolved things.” Lastly, eight students offered answers about scientists improving life. These responses included “finds out new things to help living things,” “makes life better,” and “invents things to try and help the world.”

5.3.1.14 Question 21: Do you consider yourself a scientist?

This question required a yes/no response. Eight out of thirty-five students responded affirmatively to considering themselves scientists, at 23%. Two students left it blank, and one wrote in “in the middle.”

5.3.2 Mid-survey Data

The mid-survey instrument consisted of 21 questions that were a combination of free response and affirmative/negative response. Questions were identical to those asked in the pre-survey. Twenty-six club members participated in the pre-survey, 21 seventh graders and 5 eighth graders. Mid-survey data was analyzed using cluster analysis for free response items and averages for affirmative/negative responses. This data was analyzed by the researcher and is presented below in table format followed by discussion of each result.

Table 5.2 Pre and mid-survey response categories with number of responses

QUESTION	PRECATEGORIES	#	MIDCATEGORIES	#
favorite subject	science	12	science	12
	math	4	math	2
	other inc art, French, English	22	other inc gym, French, English	12
least favorite subject	math	23	math	19
	other inc gym English, Spanish	15	other inc science, SS and English	19
extracurricular activities	sports	32	sports	16
	other inc band and chorus	4	other inc band, chorus, newsletter	8
	nothing	2	none	2
what do you do for fun	communicating with friends	26	communicating with friends	16
	sports	4	physical activities	2
	other inc reading, listening to music, being outside	8	solitary activities	7
what career are you considering	teaching	7	teaching	5
	vet/doctor/science	9	vet/doctor/science	6
	don't know and blank	8	don't know and blank	6
	other inc hairdresser, lawyer, "rockette"	12	other inc journalism, photographer, police officer, lawyer	9
why did you join the club	science is fun	31	science is fun/cool	15
	to be with friends	3	to be with friends	2
	to learn something new	4	to learn	6
			liking science	3
what do you want to learn in club	experiments	5	more about science	14
	about science	30	science careers	3
	no response	3	other inc how science helps people	7
			no response	2

Table 5.2 (Continued)

positive science experience	lab experiments	20	lab experiments	8
	at home science	4	achievement related science	12
	achievement related science	4	teachers	2
	outdoor science	6	other inc field trips and learning all the time	5
negative science experience	achievement related science	15	achievement related science	12
	lab experiments	7	lab experiments	7
	other inc teacher and people that talk in class	2	boring speakers	1
	blank (no response)	6	no response	5
	none	6	none	5
what is science	study of everything	7	study of everything	5
	study of life	5	study of life	5
	study of the world	13	study of the world/everything	4
	life	3	life	4
	everything	3	everything	5
			other inc making world better place, experiments, boring	3
what do scientists do	studies/tests things	13	discovers things	4
	does experiments	11	does experiments	10
	solves problems	6	improves the world	7
	improves the world	5	other inc boring stuff, analyzing the world	4
			no response	1

5.3.2.1 Question 1: What is your favorite subject? Why?

Responses to this question were grouped into science, math and other. Twelve students listed science as their favorite subject, two listed math, and the other twelve students listed subjects including gym, French, and English. For those who listed science, the follow up question of “Why” included “experiments,” “because it’s cool,” and “it’s fun and exciting.”

5.3.2.2 Question 2: What is your least favorite subject? Why?

Responses were grouped into two categories: math and other. A large number, nineteen students, listed math as their least favorite subject for reasons including “it’s hard to understand,” “boring,” and “it’s stupid, I’m bad at it.” One student listed science as her least favorite because “we write too much.” The remaining students listed Social Studies and English as their least favorite subject.

5.3.2.3 Question 3: What extracurricular activities do you participate in (sports, music, drama club, student council, etc.)?

Responses were grouped into two categories: sports and other. Sixteen members listed sports as an extracurricular activity, while the other ten included chorus, band, newsletter, or listed “none” (two responses).

5.3.2.4 Question 4: What do you like to do for fun?

Responses were clustered into three categories: communicating with friends, solitary activities, and physical activities. Sixteen students listed communicating with friends in various ways such as talking on the phone, and hanging out with friends. Seven students listed solitary activities including reading, drawing, and listening to music. The remaining two students listed physical activities, swimming and running/playing active games.

5.3.2.5 Question 5: What kind of career are you considering?

Career responses were grouped into four categories: teaching, vet/doctor/science related, “don’t know,” and other. Five students listed teaching as their career choice, and six listed something science related including vet and zoology. Six stated “don’t know,” “no idea,” or left it blank. The remaining nine students listed careers such as journalism, photographer, police officer, or lawyer.

5.3.2.6 Question 6: Are you planning to attend college?

This question required a “yes” or “no” response. All students, 100%, answered affirmatively to planning to attend college.

5.3.2.7 Question 7: Why did you join the Tri-Sci Club?

Responses were grouped into four categories: science is fun/cool, to be with friends, to learn, and liking science. Fifteen students responded with something related to science being fun or cool. These answers included “to have more fun learning about science” and “science rocks.” Two students joined to be with friends, and six students joined to learn. These answers included “to learn and do labs,” “to learn more things and do more experiments,” and “do labs and learn new things, fieldtrips.” Three students listed liking science as the reason for joining.

5.3.2.8 Question 8: What would you like to learn from being in this club?

Responses for this question were grouped into four categories: more about science, science careers, other, and no response. Fourteen students stated that they wanted to learn more about science, with answers including “more about science” and “new science stuff.” Three students wanted to learn more about science careers. Seven students listed other responses including “how science helps people” and “a lot of things.” Two had no response.

5.3.2.9 Question 9: Please tell us about a positive experience you have had involving science.

Responses to this prompt were divided into four categories: achievement related science, lab experiments, teachers, and other. Twelve students had a positive experience involving grades such as "good grade on my test," "good grades on homework," "doing a lab right." Eight students listed a specific lab experiment that was a positive experience. Two students listed a teacher as a positive experience, and the other five responses included "field trips" and "learning all the time."

5.3.2.10 Question 10: Please tell us about a negative experience you have had involving science.

Responses to the negative experience prompt were clustered into five categories: achievement related science, lab experiments, boring speakers, none, and no response. Twelve responses involved something related to achievement, including "getting a bad grade on a test" and "not doing a lab right." Seven responses referred to a specific experiment such as "dissecting frogs and worms" and "I got shocked." One student stated that, "the speakers were kinda [sic] boring." There were five students who wrote "none" or "don't know" indicating that they could not think of a negative experience involving science. There was one no response.

5.3.2.11 Questions 11-18 Responses to How Students Learn About Science

The following questions required yes/no responses. Percentages of affirmative responses are given for each question.

Question 11: Do you believe you are good at learning about science?

Twenty-three out of twenty-six, 88%, believed they were good at learning about science.

Questions 12 through 18 compared various factors that help students learn about science. A summary chart of these influential factors appears below, followed by descriptions of each result.

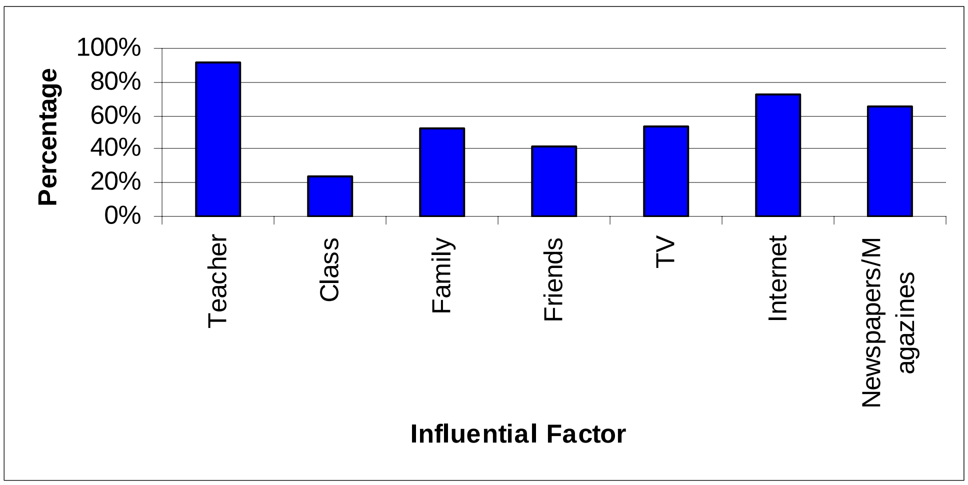

Figure 5.29 Percentage of students who responded affirmatively to questions of influential factors on the mid-survey

Question 12: Does your teacher help you learn about science?

Twenty-three out of twenty-five responses, 92%, responded affirmatively to their teachers helping them learn about science. There was one no response.

Question 13: Does your science class help you learn about science?

Six out of twenty-five responses, 24%, responded affirmatively to science class helping them learn about science. There was one "Yes and No" response, at 4% and also one no response.

Question 14: Does your family help you learn about science?

Thirteen out of twenty-five responses, 52%, responded affirmatively to family helping them learn about science. There were three “Yes and No” responses, at 12%.

Question 15: Do your friends help you learn about science?

Eleven out of twenty-six responses, 42%, responded affirmatively to friends helping them learn about science.

Question 16: Does TV help you learn about science?

Fourteen out of twenty-six responses, 54% responded affirmatively to TV helping them learn about science.

Question 17: Does the Internet help you learn about science?

Nineteen out of twenty-six responses, 73% responded affirmatively to the Internet helping them learn about science.

Question 18: Do newspapers or magazines help you learn about science?

Seventeen out of twenty-six responses, 65% responded affirmatively to newspapers or magazines helping them learn about science.

5.3.2.12 Question 19: What is science?

Responses to this question were clustered into six groups: study of everything, study of life, study of the world/everything in the world, life, everything, and other. Five students listed the study of everything, while five students listed the study of life. Four students listed study of the world or “everything around you.” Four students listed life, and five students listed everything. The other category with three responses included “it is based on life and making the world a better place,” “when you do experiments and stuff,” and “boring.”

5.3.2.13 Question 20: Please describe what a scientist does.

Responses were grouped into five categories to describe what a scientist does: discovers things, does experiments, improves the world, other, and no response. Four students listed answers involving discovery such as "discovers things" and "research and tries to create and discover." Ten students described some sort of experiment such as "does experiments to figure out thing" and "labs and experiments." Seven students responded with an answer involving improving the world. These answers included "helps people live longer" and "tests animals and finds cures." Four "other" responses included "Dunno!," "Boring stuff/more school/think," "analyzing the world around us," and "finds info about life." There was one no response.

5.3.2.14 Question 21: Do you consider yourself a scientist?

This question required a yes/no response. Five out of twenty-six responded affirmatively to considering themselves scientists, at 19%. One student wrote in "kind of" and another wrote in "maybe."

5.3.3 Post-survey Data

The post-survey instrument consisted of 21 questions that were a combination of free response and affirmative/negative response. Questions were identical to those asked in the pre-survey and also the mid-survey, with the exception of some questions that were put into past tense such as "What *did you learn* from being in this club?" Forty club members participated in the pre-survey, 22 seventh graders and 18 eighth graders. Post-survey data was analyzed using cluster analysis for free response items and averages for affirmative/negative responses. This data was analyzed by the researcher and is presented below in table format followed by discussion of each result.

Table 5.3 Pre, mid, and post-survey response categories with number of responses

QUESTION	PRECATEGORIES	#	MIDCATEGORIES	#	POSTCATEGORIES	#
favorite subject	science	12	science	12	science	11
	math	4	math	2	math	4
	other inc art, French, English	22	other inc gym, French, English	12	English	10
					other inc SS, French,art	15
least favorite subject	math	23	math	19	math	25
	other inc gym English, Spanish	15	other inc science, SS and English	19	other inc SS, English, tech, Spanish	15
extracurricular activities	sports	32	sports	16	sports	24
	other inc band and chorus	4	other inc band, chorus, newsletter	8	music	7
	nothing	2	none	2	other inc drama club, science club	5
					none	4
what do you do for fun	communicating with friends	26	communicating with friends	16	communicating with friends	19
	sports	4	physical activities	2	physical activities	18
	other inc reading, listening to music, being outside	8	solitary activities	7	solitary activities	3
what career are you considering	teaching	7	teaching	5	lawyer	7
	vet/doctor/science	9	vet/doctor/science	6	science related	9
	don't know and blank	8	don't know and blank	6	television related	3
	other inc hairdresser, lawyer, "rockette"	12	other inc journalism, photographer, police officer, lawyer	9	don't know	3
					other inc photographer, chef, cosmetologist, electrician	18
why did you join the club	science is fun	31	science is fun/cool	15	to have fun	17
	to be with friends	3	to be with friends	2	to be with friends	2
	to learn something new	4	to learn	6	to learn science	16
			liking science	3	to do experiments	4
					don't know	1
what do you want to learn in club	experiments	5	more about science	14	specific science experiments	17
	about science	30	science careers	3	science careers	6
	no response	3	other inc how science helps people	7	general science	14
			no response	2	other inc things I didn't know	2
					no response	1

Table 5.3 (Continued)

positive science experience	lab experiments	20	lab experiments	8	lab experiments	12
	at home science	4	achievement related science	12	achievement related science	7
	achievement related science	4	teachers	2	field trips	15
	outdoor science	6	other inc field trips and learning all the time	5	other inc learning about world, tri-sci makes it fun	3
					no response	3
negative science experience	achievement related science	15	achievement related science	12	achievement related science	14
	lab experiments	7	lab experiments	7	lab experiments	10
	other inc teacher and people that talk in class	2	boring speakers	1	real life science	3
	blank (no response)	6	no response	5	no response	3
	none	6	none	5	none	5
					other inc lectures, doing book work	5
what is science	study of everything	7	study of everything	5	study of everything	5
	study of life	5	study of life	5	study of life	5
	study of the world	13	study of the world/everything	4	study of the world	23
	life	3	life	4	everything	4
	everything	3	everything	5	other inc boring, fun, doing experiments	3
			other inc making world better place, experiments, boring	3		
what do scientists do	studies/tests things	13	discovers things	4	problem solves	6
	does experiments	11	does experiments	10	performs experiments	11
	solves problems	6	improves the world	7	improves the world	6
	improves the world	5	other inc boring stuff, analyzing the world	4	observes the world	5
			no response	1	other inc researches everything, studies science	10
					no response	2

5.3.3.1 Question 1: What is your favorite subject? Why?

Responses to this question were grouped into science, math, English and other. Eleven students listed science as their favorite subject, four listed math, and ten listed English. Other responses included Social Studies, French, and Art. For those who listed science, the follow up question of “Why” included “it’s fun to do the labs” “learn new stuff you don’t know about,” and “we get to actually demonstrate and work things out instead of just listen [sic] to the teacher read.”

5.3.3.2 Question 2: What is your least favorite subject? Why?

Responses were grouped into two categories: math and other. A large number, twenty-five students, listed math as their least favorite subject for reasons including “I don’t understand it,” “I have trouble in it,” and “very difficult to understand and too much work.” The remaining fifteen students listed Social Studies, English, Tech, and Spanish as their least favorite subjects.

5.3.3.3 Question 3: What extracurricular activities do you participate in (sports, music, drama club, student council, etc.)?

Responses were grouped into four categories: sports, music, other, and none. Twenty-four members listed sports as an extracurricular activity. Seven students listed music (band or chorus) as an extracurricular activity. Five students listed other activities such as drama club and science club. Four students listed “none.”

5.3.3.4 Question 4: What do you like to do for fun?

Responses were clustered into three categories: communicating with friends, physical activities, and solitary activities. Nineteen students listed communicating with friends in various ways such as talking on the computer and hanging out with friends. Eighteen students listed physical activities as a fun activity. Three students listed solitary activities including reading and listening to music.

5.3.3.5 Question 5: What kind of career are you considering?

Career responses were grouped into five categories: lawyer, science related, television related, don't know, and other. Seven students listed lawyer as a career. Nine students listed a career related to science. These included "zookeeper," "pediatrician," and "orthodontist." Television related careers were listed by three students and included "actress" and "anything in the entertainment business behind cameras or in front of cameras." Three students listed don't know as their answer, and the remaining eighteen students listed other careers including photography, chef, cosmetologist, electrician, and many others.

5.3.3.6 Question 6: Are you planning to attend college?

This question required a "yes" or "no" response. Thirty-eight out of forty students, 95%, responded affirmatively to the question of attending college. One student responded, "Yes and No" and one student had no response.

5.3.3.7 Question 7: Why did you join the Tri-Sci Club?

Responses were grouped into five categories: to have fun, to learn science, to do experiments, and to be with friends, and don't know. Seventeen students listing having fun as the reason for joining, and these responses included, "it sounded fun" and "because science is fun and interesting. Sixteen students listed learning science as the reason for joining. These responses included "to learn about the environment and work with people" and "to learn more about science." Four students stated that experiments were the reason they joined, which included "to do experiments, I like hands-on projects" and "to do labs." Two students listed their friends as reasons for joining, and there was one response of "don't know."

5.3.3.8 Question 8: What did you learn from being in this club?

Responses for this question were grouped into five categories: specific science experiments, science careers, general science, other, and no response. Seventeen students listed specific science experiments that were conducted during the year including electricity, circuits, lemon batteries, computer chips, and many others. Six students listed science careers as something they learned. These responses included, “I learned that there are many females in science fields and they're all important to studies [sic]” and “a lot about science and some of the many different scientific jobs that are available.” Fourteen students learned general things about science such as “more about science” and “science applies to everyday life and a lot of big words I don't remember.” Other responses were “this is the first time coming (to the club)” and “things I didn’t know.” There was one no response.

5.3.3.9 Question 9: Please tell us about a positive experience you have had involving science.

Responses to this prompt were divided into five categories: field trips, achievement related science, lab experiments, other, and no response. Fifteen students listed field trips as a positive experience. The most common response was the “Sciencenter.” Achievement related science had seven responses which included “getting good grades” and “doing experiments right.” Twelve students listed specific lab experiments as a positive experience. These included “studying minerals through microscopes” and “building electrical circuits.” Three other responses were “learning more about the world,” “tri-sci makes it fun,” and “when I’m involved in hands on experiences.” There were three no responses.

5.3.3.10 Question 10: Please tell us about a negative experience you have had involving science.

Responses to the negative experience prompt were clustered into six categories: achievement related science, lab experiments, real life science, other, none, and no response. Fourteen students listed an achievement related negative science experience, including “failing a test,” “notebook checking,” and “not doing experiments right.” Ten students listed a specific lab experiment as negative, such as “dissecting” and “I almost made a fire start.” Three students listed an experience in ordinary life as negative. These included “gravity/going down hill on a skateboard,” “I experienced gravity on a bike,” and “being stung by a bee.” Five students listed other experiences, including “lectures and “doing book work.” Five students listed “none,” indicating they did not recall a negative science experience, and there were three no responses.

5.3.3.11 Questions 11-18 Responses to How Students Learn About Science

The following questions required yes/no responses. Percentages of affirmative responses are given for each question.

Question 11 Do you believe you are good at learning about science?

Thirty-six out of forty students, 90%, believed they were good at learning about science. One student answered “Yes and No.”

Questions 12 through 18 compared various factors that help students learn about science. A summary chart of these influential factors appears below, followed by descriptions of each result.

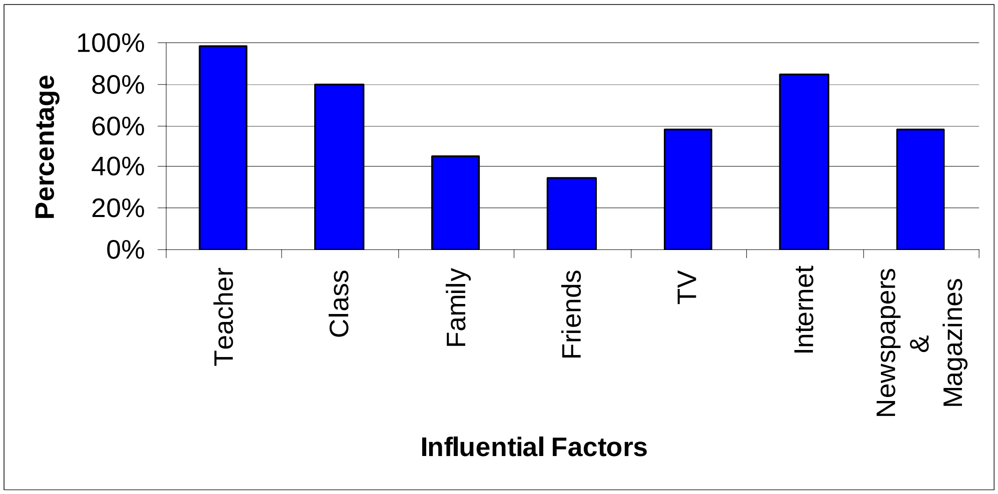

Figure 5.30 Percentage of students who responded affirmatively to questions of influential factors on the post-survey

Question 12: Does your teacher help you learn about science?

Thirty-nine out of forty responses, 98%, responded affirmatively to their teachers helping them learn about science.

Question 13: Does your science class help you learn about science?

Thirty-two out of forty responses, 80%, responded affirmatively to science class helping them learn about science.

Question 14: Does your family help you learn about science?

Eighteen out of forty responses, 45%, responded affirmatively to family helping them learn about science. There were two "Sometimes" responses, at 5%.

Question 15 Do your friends help you learn about science?

Fourteen out of forty responses, 35%, responded affirmatively to friends helping them learn about science.

Question 16: Does TV help you learn about science?

Twenty-three out of forty responses, 58% responded affirmatively to TV helping them learn about science. Two students responded "Sometimes," at 5%.

Question 17: Does the Internet help you learn about science?

Thirty-four out of forty responses, 85% responded affirmatively to the Internet helping them learn about science. One student responded “Sometimes,” at 3%.

Question 18: Do newspapers or magazines help you learn about science?

Twenty-three out of forty responses, 58% responded affirmatively to newspapers or magazines helping them learn about science. Two students responded “Sometimes,” at 5%.

5.3.3.12 Question 19: What is science?

Responses to this question were clustered into five groups: study of everything, study of life, study of the world, everything, and other. Five students listed the study of everything, while five students listed the study of life. Twenty-three students listed study of the world or “study of everything around you.” Four students listed everything. The other category with three responses included “boring,” “fun—try to figure something out,” and “doing experiments—finding things out.”

5.3.3.13 Question 20: Please describe what a scientist does.

Responses were grouped into six categories to describe what a scientist does: performs experiments, problem solves, observes the world, improves the world, other, and no response. Eleven students listed experiments as what a scientist does. These responses included “experiment, make new formulas” and “experiments a lot.” Six students listed problem solving as a scientist activity, which included “figures out problems and studies the things around” and “tries to figure something out.” Five students stated that scientists observe the world, which included “they observe the world,” and “a scientist looks at different things and puts them in groups.” Six students listed answers related to improving the world. These responses included “they try to discover things to help the world,” “studies science stuff to make our lives better,” and “studies a certain subject to improve the world.” Ten other responses were varied and included “researches everything or anything,” “studies science things,” and “researches information.” There were two no responses.

5.3.3.14 Question 21: Do you consider yourself a scientist?

This question required a yes/no response. Twenty-two out of thirty-nine students considered themselves a scientist, at 56%. There was one no response. Two students wrote in “Maybe,” while three students wrote in “Yes and No.” One of the negative responses included the comment “No, but maybe someday…”

5.4 Post-interview Results

The post-interview instrument consisted of 21 questions that were a combination of free response and affirmative/negative response. Twenty-four club members participated in the post-interview, 8 seventh graders and 16 eighth graders. Post-interview data was collected by phone by the researcher and then transcribed. After transcription, data was analyzed by the research and the teachers to determine which questions elicited the richest responses and would therefore be the best candidates for cluster analysis. The questions that were selected for cluster analysis were the following: Can you tell me a little more about why you joined the science club?; What did you learn from being in the club?; Can you tell me about a positive experience you’ve had involving science?; Can you tell me about a negative experience you’ve had involving science?; What is science?; What do scientists do?.

After these questions were selected, cluster analysis was used to sort the interview responses into like piles. This analysis was done by the researcher and the teachers separately to add validity to the analysis. After these categories were determined, the researcher then reduced the list of categories to eliminate duplicates and then analyzed the data a final time using this consolidated list. The list of categories used for each question appears below, followed by the analysis of the data using those specific categories.

Overall, the interviews indicated that most girls who participated in the intervention did so because they had a predisposition for enjoying science. These girls generally felt good about science because of good grades, fun science experiments, and enrichment activities such as field trips. The girls recalled positive science experiences such as specific lab activities when asked to reflect on what they learned through the intervention program. They had a hard time recalling negative science experiences, and those that did listed things like dissecting animals and getting bad grades, neither of which were part of the intervention program. These negative experiences were from formal class instruction.

The interviews also brought out standard definitions of science such as the study of everything, indicating that the girls' definitions of science may have been formed at school rather than at home or through leisure activities. The girls viewed scientists as improving the world through the search for new medicines and cures for disease, or alternatively as people who shared information about science through news reports and teaching. Overall, impressions of scientists were positive throughout the school year. We will now look at each question with its specific results. Synthesis of these results as well as integration with results from other instruments follows in Chapter 6, Discussion.

5.4.1 Questions and Results

Question 4: Can you tell me a little more about why you joined the science club?

The twenty-four responses were grouped into the following categories: fun, sounded interesting, specific science topics, like experimenting, like science, learn more science, and don't know. There were four responses related to fun, two responses for sounded interesting, two responses for specific science topics, four responses for like experimenting, five responses for like science, five responses for learn more science, and one don't know response.

Question 5: What did you learn from being in the club?

Categories for this question were: fun, learn something about science, specific lessons, field trips, and no response. There was once response related to fun, two responses to learning something about science, fourteen responses related to specific lessons, two responses related to field trips, and five no response.

Question 6: Can you tell me about a positive experience you've had in science?

Categories for this question were: experiments, good grades, fun, learning, field trips, don't know, and no response. There were three responses related to experiments, five responses related to good grades, three responses related to fun, two related to learning, two related to field trips, four don't know, and five no response.

Question 7: Can you tell me about a negative experience you've had in science?

Categories for this question were: tests/grades, dissecting/biology, trouble understanding, no, and don't know. There were six responses related to tests/grades, four related to dissecting/biology, two related to trouble understanding, eleven no negative experiences, and one don't know.

Question 16: What is science?

Categories for this question were: study of Earth, study of living and nonliving things, study of everything, learning about the world, doing experiments/solving problems, no response, and don't know. There were two responses each to study of Earth and study of living and nonliving things, nine responses related to study of everything, six responses to learning about the world, two responses to doing experiments/solving problems, one don't know, and two no response.

Question 17: What do scientists do?

Categories for this question were: make the world better, medicine/cures, test and experiment, study and research, share information and teach, and no response. There were two responses related to making the world better, seven response to medicine/cures, three related to test and experiment, five related to study and research, four related to share information and teach, and three no response.

CHAPTER 6

DISCUSSION

6.1 Overview of Synthesis

In this chapter, we will look separately at the results from each instrument: TOSRA, surveys, and interviews. We will then integrate findings from each instrument into a coherent whole that considers the differences that occurred over time during the course of a school year. Using quantitative data from the TOSRA, we will focus on students who participated in the intervention program and will draw comparisons between students in the intervention and students not in the intervention. The qualitative data from surveys will be viewed across the course of the school year to look for differences over time in the factors that influenced girls' attitudes toward science. The interview data will be analyzed for nuances that may not have been drawn out in the survey data.

We will then step back from the analysis and speculate about what factors influenced the results of this study. Using the lens of social construction of knowledge and the roles of context, self and experience, we will cast the results into a framework to theorize about what is occurring with middle school girls that can help us elucidate the results of the study.

6.2 TOSRA Synthesis

To frame our discussion of the TOSRA data, we will look again at the hypotheses that form the basis for the study and determine if we can reject the null hypothesis for each research question.

6.2.1 Overall TOSRA Synthesis

Research Question 1: Do attitudes toward science change during the course of the school year in grades 7 and 8?

Hypothesis 1: Attitudes toward science among students in grades 7 and 8 will decrease during the course of the school year.

The TOSRA was administered at the beginning, middle, and end of the school year to all students in grades 7 and 8. Based on prior research that utilized the TOSRA instrument, it was expected that when results were analyzed, student attitudes toward science in both grade levels would decrease over time. In analyzing the data, we find that the overall scores of students in grades 7 and 8 combined dropped from the beginning of the year to the end, with the lowest scores recorded at mid year. This change in scores was statistically significant (P=.02), so we can reject the null hypothesis and accept our hypothesis. Attitudes toward science in grades 7 and 8 decreased during the course of the school year.

However, when we separate out the data and analyze each grade level individually, we find that grade seven attitudes showed a slight increase over time. Grade eight students began quite high and dropped dramatically by the middle of the year. Two possible explanations could account for this midyear drop in scores. The first is what can be thought of as the “summer effect,” in that initial scores at the beginning of the school year were higher than normal because students just returned from having two months away from school. Another possible explanation is the midyear tests for all eighth graders that are taken in January. The timing of these tests immediately preceded implementation of the TOSRA at midyear, and the negative attitudes toward science could be influenced by the negative attitudes toward testing. This theory is supported by the qualitative data collected from girls participating in the intervention, as one of the most common negative science experiences reported by girls was tests.

Research Question 2: Does a science club for girls influence girls' attitudes toward science in grades 7 and 8, and is there a difference in attitude change between grades 7 and 8?

Hypothesis 1: Girls who self-select to participate in the science club for girls will have higher attitudes toward science at beginning, middle, and end of the year than girls who choose not to participate.

TOSRA data was compared between girls who self-selected to participate in the science club and girls who chose not to participate in grades 7 and 8. It was expected that girls who self-selected to participate in the science club would have higher attitudes toward science than those who chose not to participate. It was also expected that this trend would be observable at beginning, middle and end of the year. There was not a statistically significant difference between those who chose to participate in the intervention and those who chose to participate in grades 7 and 8. There was no effect of the intervention by grade by time (P=0.25), so we must accept the null hypothesis.

A possible explanation for the lack of a significant difference can be found in sample size. There were 46 girls in the club and 39 girls not in the club. If we could double the sample size, then we would increase the statistical power and might reach different conclusions.

Hypothesis 2: Intervention in the form of a hands-on science club will maintain or increase girls' positive attitudes toward science.

TOSRA data was analyzed for girls who self-selected to participate in the science club for girls. It was expected that attitudes toward science of girls who self-selected to participate in the science club would remain the same or increase during the course of the school year. There was no effect of the intervention on scores over time ($P = 0.86$), so we must accept the null hypothesis.

As was seen in data for the previous hypothesis, although there was not a statistically significant difference over time, the average scores for girls in the club were higher at all three time points than scores for students not in the club. We see again that increasing the sample size could change the results of this hypothesis test.

Hypothesis 3: For all participants studied, there will be a greater change in attitude at grade 7 than at grade 8.

TOSRA data was compared between students in grade 7 and grade 8. It was expected that there would be a greater negative total change in attitude for students in grade 7 than in grade 8. Indeed, this was not the case. Scores for students in grade 8 changed more dramatically during the course of the school year than scores for students in grade 7. The grade by time effect was statistically significant ($P = 0.05$), but the results were the opposite of what was expected (grade 8 showed more change than grade 7), so we must accept the null hypothesis.

As was mentioned in Research Question 1, Hypothesis 1, the grade 8 scores showed a significant change over time. Factors that are believed to have influenced this result are the “summer effect” and the impact of high stakes tests on midyear scores.

6.2.2 TOSRA Subscale Synthesis

After analyzing the overall TOSRA data, we can look at each subscale individually to determine if there were differences between student responses on each scale. The subscales were: Social Implications of Science, Normality of Scientists, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science. Significant differences were seen in only three of the seven scales: Normality of Scientists, Enjoyment of Science Lessons, and Leisure Interest in Science.

Table 6.1 TOSRA subscale comparisons with corresponding p-values

TOSRA Subscale	**Comparison**	**P-value***
Social Implications of Science	girls who did and did not participate in club	0.82
	all students who did and did not participate in club	0.88
	all students in grade seven and grade eight	0.07
Normality of Scientists	girls who did and did not participate in club	**0.004**
	all students who did and did not participate in club	**0.025**
	all students in grade seven and grade eight	0.67
Attitude to Scientific Inquiry	girls who did and did not participate in club	0.21
	all students who did and did not participate in club	0.26
	all students in grade seven and grade eight	0.36
Adoption of Scientific Attitudes	girls who did and did not participate in club	0.71
	all students who did and did not participate in club	0.88
	all students in grade seven and grade eight	0.13
Enjoyment of Science Lessons	girls who did and did not participate in club	0.54
	all students who did and did not participate in club	0.91
	all students in grade seven and grade eight	**0.0249**
Leisure Interest in Science	girls who did and did not participate in club	0.25
	all students who did and did not participate in club	0.30
	all students in grade seven and grade eight	**0.0356**
Career Interest in Science	girls who did and did not participate in club	0.36
	all students who did and did not participate in club	0.50
	all students in grade seven and grade eight	0.1033

* Bolded values represent significance of P = 0.05 or greater

Within the Normality of Scientists scale, there was an effect of club by grade by time (see Figure 5.9). Grade seven scores for girls not in the club were higher at both midyear and end of the year than scores for girls in the club. This indicates that attitudes toward Normality of Scientists within grade seven girls were lower as the year progressed for girls participating in the science club intervention program than for girls not participating in the program. However, even though those in the club had lower scores, the career/role modeling activities during the second half of the year appear to have had a positive effect on the Normality of Scientists scores. Those in the club dropped to the lowest scores at midyear, after the hands-on activities, and then gained ground by the end of the year, after the career/role modeling activities. Further study would be needed to figure out what exactly caused the rise in scores, but it is plausible that the career/role modeling activities contributed to girls' positive feelings about Normality of Scientists.

Grade eight scores showed a different result; those girls in the club had higher attitudes toward Normality of Scientists as the year progressed than girls not in the club. The grade eight intervention for the first half of the year was career/role model activities, followed by hands-on activities during the second half of the year. Scores rose from beginning to middle of the year and then rose even more sharply in the second half of the year. Since there was a greater increase in attitudinal scores regarding Normality of Scientists for eighth grade girls in the club during the second half of the year, we can infer that the hands-on activities were more positively received than the career/role modeling activities. Both types of intervention appear to have impacted the scores as evidenced by the gradual increase over time. When we look at the grade seven and grade eight results comparatively, we can infer that the club had an effect on attitudes toward Normality of Scientists for both grade levels.

However, when comparing within grade seven girls, we see that the club led to lower scores than no club.

We can then explore the data for Normality of Scientists including boys as well as girls, and we find that there was also an effect of club by grade by time when including the boys' data (see Figure 5.11). Including the boys' data did not cause any shifts in trends. Grade seven scores for those in the club showed a gradual decrease just as they had when looking at data for girls only, and scores for grade eight in the club showed an increase over time as they had in the data including only girls. These shifts over time were more pronounced when looking at the girls' data exclusively, most likely due to the smaller sample size.

Another subscale that saw differences over time was Enjoyment of Science Lessons (see Figure 5.21). There was an effect of grade by time between grades seven and eight. Grade seven scores for attitudes toward Enjoyment of Science Lessons increased over time, while grade eight scores decreased between the beginning and middle of the year and then increased slightly by the end of the year. Grade eight scores ended at a lower point than the beginning of the year, despite the slight increase between middle and end of the year. We can see, then, that grade seven students had increasingly positive feelings toward science lessons as the year progressed. Grade eight students had the least positive feelings toward science lessons at the middle of the year and also had less positive feelings at the end of the year than at the beginning.

These results related to Enjoyment of Science Lessons could be due to the influence of the classroom environment on student attitudes. Grade eight is a "high stakes" year for students in science, since they are preparing for the standardized test that is given at the end of the year. Grades on tests and lab activities are more critical for eighth graders than seventh graders, because they indicate preparedness for the standardized testing. Student responses to survey questions about why they liked or did not like certain subjects can also inform our conclusions about what impacted these students. Content that was too hard and mean teachers were two reasons that students disliked certain subjects throughout the year. And when asked to list negative science experiences, more eighth graders than seventh graders listed bad grades on tests and mean teachers on their surveys, which could help to explain why their enjoyment of science decreased during the year while seventh grade enjoyment increased.

The Leisure Interest in Science subscale also saw grade level differences over time (see Figure 5.24). Grade seven attitudes toward Leisure Interest in Science increased throughout the year. The same pattern for grade eight emerged that was seen in the Enjoyment of Science Lessons subscale. Grade eight scores decreased between the beginning and middle of the year and then increased by the end of the year, with a final score lower than the initial score for the year. Again, there is a similarity between these two subscales. We see that grade seven students had increasingly positive associations toward Leisure Interest in Science, while the grade eight students had increasingly negative associations toward Leisure Interest in Science between the beginning and middle of the year. Grade eight student scores for Enjoyment of Science Lessons rebounded slightly by the end of the year, but their final scores were lower than the beginning scores.

Although the subscales are supposed to measure the influence of independent variables, some of the same factors that influenced the Enjoyment of Science Lessons scale could also have impacted the Leisure Interest in Science scale. Expectations of eighth graders in science are much more rigorous than expectations for seventh graders because of the testing schedule, and it is logical that if Enjoyment of Science Lessons decreases, so will Leisure Interest in Science. Negative feelings toward something can spread from one environment to another. In this case, the negative feelings toward in-school science could spread to at-home science and impact how students engage with science content and activities outside the school setting.

Exploring each subscale within the TOSRA data allows us to see more detail about what influences student attitudes toward science. Only three subscales showed statistically significant differences over time. The first one that was significant over time when considering club and grade, Normality of Scientists, did not show the same results as the overall TOSRA data (see Figure 5.5). Overall TOSRA data did not show a club by grade by time effect as did the Normality of Scientists subscale. However, the results found in the two subscales Enjoyment of Science Lessons and Leisure Interest in Science corroborate results from overall TOSRA scores over time for students in grade seven and grade eight (see Figure 5.3). In these two subscales and in overall TOSRA data, there were two patterns that emerged. For grade seven students, scores in these three analyses increased from beginning to middle to end of the year. For grade eight students, scores began high, dropped to a low at midyear, and then rebounded to end at a point lower than the initial scores.

Other than within these three subscales, there were no statistically significant findings in the subscales and no comparisons can be drawn between overall TOSRA data and data for each subscale. However, we can look at the results from these analyses and consider what is influencing the scores over time. We can use what we know about how students learn and what impacts their learning to draw conclusions about factors in the school environment that could influence student attitudes. We will turn now to the qualitative data from surveys and interviews to look for trends over time that could support findings in the TOSRA data.

6.3 Survey Synthesis

To gain a deeper understanding of the self-selection that occurred among the girls who participated in the intervention and to help provide context for their attitudes, surveys were used at the beginning, middle, and end of the school year. As we look across these surveys, we can see differences between data collected at various times. The table below shows the data in summary format and is followed by discussion of the results for each question.

Table 6.2 Categories from pre, mid, and post-surveys of participants with number of responses

QUESTION	PRECATEGORIES	#	MIDCATEGORIES	#	POSTCATEGORIES	#
favorite subject	science	12	science	12	science	11
	math	4	math	2	math	4
	other inc art, French, English	22	other inc gym, French, English	12	English	10
					other inc SS, French,art	15
least fav subject	math	23	math	19	math	25
	other inc gym English, Spanish	15	other inc science, SS and English	19	other inc SS, English, tech, Spanish	15
extracurricular activities	sports	32	sports	16	sports	24
	other inc band and chorus	4	other inc band, chorus, newsletter	8	music	7
	nothing	2	none	2	other inc drama club, science club	5
					none	4
what do you do for fun	communicating with friends	26	communicating with friends	16	communicating with friends	19
	sports	4	physical activities	2	physical activities	18
	other inc reading, listening to music, being outside	8	solitary activities	7	solitary activities	3

Table 6.2 (Continued)

what career are you considering	teaching	7	teaching	5	lawyer	7
	vet/doctor/science	9	vet/doctor/science	6	science related	9
	don’t know and blank	8	don’t know and blank	6	television related	3
	other inc hairdresser, lawyer, “rockette”	12	other inc journalism, photographer, police officer, lawyer	9	don’t know	3
					other inc photographer, chef, cosmetologist, electrician	18
why did you join the club	science is fun	31	science is fun/cool	15	to have fun	17
	to be with friends	3	to be with friends	2	to be with friends	2
	to learn something new	4	to learn	6	to learn science	16
			liking science	3	to do experiments	4
					don’t know	1
what do you want to learn in club	experiments	5	more about science	14	specific science experiments	17
	about science	30	science careers	3	science careers	6
	no response	3	other inc how science helps people	7	general science	14
			no response	2	other inc things I didn’t know	2
					no response	1
positive science experience	lab experiments	20	lab experiments	8	lab experiments	12
	at home science	4	achievement related science	12	achievement related science	7
	achievement related science	4	teachers	2	field trips	15
	outdoor science	6	other inc field trips and learning all the time	5	other inc learning about world, tri-sci makes it fun	3
					no response	3
negative science experience	achievement related science	15	achievement related science	12	achievement related science	14
	lab experiments	7	lab experiments	7	lab experiments	10
	other inc teacher and people that talk in class	2	boring speakers	1	real life science	3
	blank (no response)	6	no response	5	no response	3
	none	6	none	5	none	5
					other inc lectures, doing book work	5
what is science	study of everything	7	study of everything	5	study of everything	5
	study of life	5	study of life	5	study of life	5
	study of the world	13	study of the world/everything	4	study of the world	23
	life	3	life	4	everything	4
	everything	3	everything	5	other inc boring, fun, doing experiments	3
			other inc making world better place, experiments, boring	3		

Table 6.2 (Continued)

what do scientists do	studies/tests things	13	discovers things	4	problem solves	6
	does experiments	11	does experiments	10	performs experiments	11
	solves problems	6	improves the world	7	improves the world	6
	improves the world	5	other inc boring stuff, analyzing the world	4	observes the world	5
			no response	1	other inc researches everything, studies science	10
					no response	2

For the first survey question, “What is your favorite subject?” the pre-survey and mid-survey data were very similar in that many girls listed science and math as their favorite subjects. Reasons for liking science across all three time periods revolved around science being fun and liking the hands-on experiments. In the post-survey, English emerged as another favorite subject with a similar number of girls listing it. The second question, “What is your least favorite subject?” found math as the least favorite subject across all three time periods. Reasons for disliking math involved being “bad” at it, finding it too difficult to understand, and having a “mean teacher.” The girls were consistent in not liking subjects that were too hard or in which they did not excel.

To gain a sense of the girls’ involvement in other activities and explore their interests outside of the club, the question “What extracurricular activities do you participate in?” was asked. For the first two survey periods, sports and humanities activities were common activities amongst the girls. In the last survey period, music related activities were more common than in the first two, and sports and humanities in general remained high. An interesting increase occurred in students who listed either nothing or wrote “none.” There were only two girls in the first and second survey periods who did not participate in any other extracurricular programming, and the number doubled to four in the final survey period. This could be due to additional club members joining or to students dropping activities as the year progressed. The girls who participated in the club typically were involved in many other activities, and so the expectation that the club would have a significant impact on their lives is optimistic. If the science club is the only activity in which a particular girl participates, then it is possible that it has a greater impact on her than on other girls who are involved in multiple extracurricular events.

The question “What do you like to do for fun?” was asked to help us better understand what the girls liked to do so that we could tailor some of the activities of the club to their interests. Sports and communicating with friends through phone, email and in person were the most popular fun activities. This is not surprising, as teenagers generally prefer social activities to solitary ones. However, there were a number of students who listed some sort of solitary activity such as reading or listening to music as their fun activity. The number of students who listed a solitary activity decreased from the pre-survey (8 students) to the mid-survey (7 students) and again to the post-survey with only three students listing reading or listening to music during the final survey period. Knowing that most students liked kinesthetic and social activities more than solitary ones, we were able to offer activities throughout the year in which students worked in pairs, attended field trips, and participated in other active programming. It was expected that this social interaction with peers would enhance positive attitudes toward science.

The career related question “What kind of career are you considering?” prompted responses on the pre-survey and mid-survey that related to teaching and science related careers. Interestingly, on the post-survey, teacher was replaced by lawyer as a career choice. Science related careers including vet and doctor remained a strong choice with nine students listing it on the pre-survey, six listing it on the mid-survey, and nine on the post-survey. In general, the responses were more varied during the last survey period. Part of the reason for this variation could be that the eighth graders participated in career related curriculum during the year as part their formal instruction, which could have influenced their career aspirations. It is difficult for a once or twice per month intervention to compete with the daily curricula of a school, which typically has very different goals from the intervention program. The intervention is diluted by the dominant forces (including formal curricula) within a normal school day.

The affirmative/negative question “Are you planning to attend college?” elicited similar percentages throughout the year. At the pre-survey, 97% of students planned to attend college, and the number increased to 100% at mid-year but then dropped to 95% by the final survey period. The career/role model activities in the intervention featured several female college students who were science majors, and these role models apparently did not positively influence girls’ thoughts about attending college. It is hard to determine what caused this slight shift over time without further study.

To determine the motivation for joining the club, we asked “Why did you join the Tri-Sci Club?” Across all three survey periods, having fun was the most listed reason for joining. It is not clear what girls mean by “having fun,” but we can look at the other responses to this question and also look at other questions including “What do you like to do for fun?” to provide insight. For the current question of why they joined, other reasons that appeared during all three periods were being with friends and learning. If we look at the prior question about what they like to do for fun, the answers were mostly sports and communicating with friends. If we combine this information, then it appears that the science club provided a forum for active participation (like that found in sports) and for being with friends (communicating with friends). It is hard to determine exactly what is behind the students' answers, but we can use reasoning to make certain assumptions.

The question "What would you/did you like to learn from being in this club?" was asked to determine what the girls were most interested in learning about during the school year. This information helped us probe a little deeper into why the girls joined the club. Did they join to learn something specific, or was learning a byproduct of joining the club? There was quite a bit of variation over time in the answers. A very general response about science was consistent across time periods. The only other response in the pre-survey was experiments, but then in the mid-survey and post-survey periods, careers emerged as something the girls wanted to learn from participating in the club. It is possible that the career/role modeling portion of the intervention program prompted the girls to add this category to their collective responses. During the post-survey period, six students out of forty (15%) listed science careers as something they learned. These responses included, "I learned that there are many females in science fields and they're all important to studies [sic]" and "a lot about science and some of the many different scientific jobs that are available." As one of the club goals was to expose the girls to career options in science through guest speakers, this result was encouraging. Also in the post-survey, specific rather than general science experiments dominated. Girls listed many of the experiments that they had performed during science club as things that they learned. This affirmed the idea that the science club encouraged girls to learn about science.

We asked girls to describe a positive science experience in the prompt, “Please tell us about a positive experience you have had involving science.” Achievement related science and lab experiments were common responses to this prompt during all three survey periods. At the pre-survey, lab experiments were the most frequent response with achievement a close second. By the mid-survey, achievement related science moved up to the most frequent response and included good grades and doing experiments right. It is possible that girls were more focused on grades by the middle of the year, particularly the eighth grade girls who were preparing for the standardized test. Achievement remained a popular response at the post-survey period, but it was displaced by field trips as the most common response. A specific field trip to the Sciencenter that occurred a few weeks prior to the post-survey collection and was mentioned by many girls could have influenced responses to this question. An interesting thing to note is that at the pre-survey period, four girls listed some sort of at-home science experience as a positive one, but then no one listed a similar type of experience at either the mid-survey or post-survey periods. We could infer that as girls became more involved with science in school, they began to think of science as a school-related activity rather than an at-home activity. Previously explained results on the attitude scales of Enjoyment of Science Lessons and Leisure Interest in Science confirm this finding (Section 2.2.2).

The opposite question, “Please tell us about a negative experience you have had involving science” drew consistent responses across the three survey periods. Achievement related science was consistently the most frequent negative response and included bad grades, notebook checking, and doing an experiment wrong. Lab experiments were the next most frequent response during all three periods, and these responses included dissecting things and experiments gone awry. Another common response across all three survey periods was “none,” indicating that the girls could not think of a negative science experience. It would be a worthy goal to increase this number in future studies.

The next question asked was, “Do you believe you are good at learning about science?” The percentage of girls who responded affirmatively to this question increased over time from 81% to 90%. Although we cannot determine exactly what caused this increase, it is possible that the intervention program contributed to the positive feelings about science learning that girls reported.

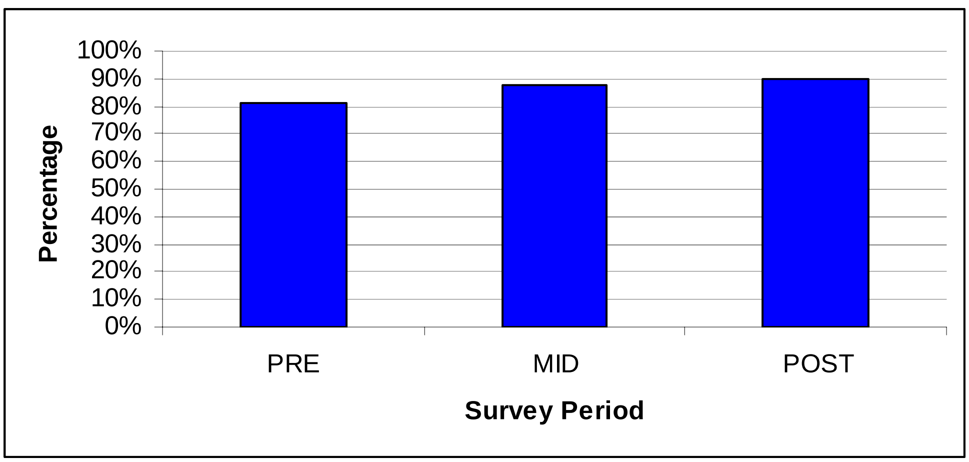

Figure 6.1 Percentage of respondents who believe they are good at learning about science

Many specific factors influence how girls learn about science. When we look across the three survey periods, we see that there were some differences over time in what influenced how girls learned science. Teachers, family, television, and newspapers/magazines were consistent influences. Less consistent were science class, friends, and Internet. Teachers were the most influential at all time points, while the Internet gained influence over time. Family and friends were the least influential factors, which is surprising since family and friends are typically viewed as very influential during the teenage years.

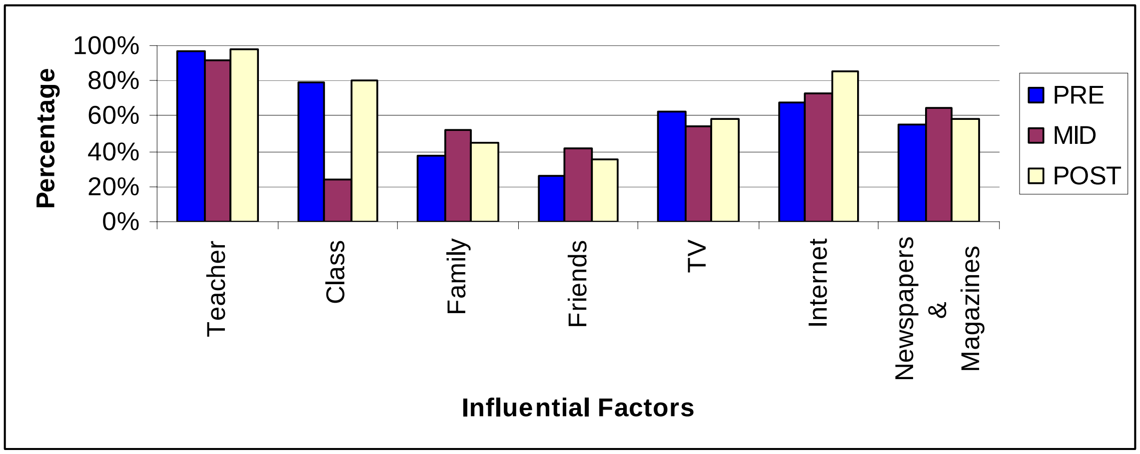

Figure 6.2 Factors that influence how girls learn about science during three survey periods

In an effort to understand how girls view science, we asked "What is science?" The most frequent answer during the first survey period was study of the world, with study of everything as the second most frequent response. During the second period, study of everything and study of life were equally distributed, with study of the world as a close second. In the last period, most students listed study of the world, with equal numbers listing study of everything and study of life. It seems that the girls gave very standard definitions of science, definitions that were learned in school. Science to them is the study of everything, study of the world, and study of life. In essence, these definitions are all the same.

The career speakers that participated in the intervention were all practicing scientists, so we asked the girls to "Please describe what a scientist does." The same ideas appeared at all three time points, but at different rates. During the pre-survey period, the most common response was that scientists study or test things, whereas the most common response at mid-survey and post-survey was that scientists experiment to figure things out and to discover things. A consistent number of girls believed that scientists improve the world, with responses including "helps people live longer" and "they try to discover things to help the world." Since several of the career speakers discussed scientific discovery and health applications, we can infer that their stories impacted the girls' responses. In general, girls' perceptions of scientists were positive.

The question "Do you consider yourself a scientist?" drew different affirmative response rates, with the lowest percentage of affirmative responses at mid year. The pre-survey response was 23% affirmative, with the mid-survey response at 19% and the final survey response at 56% affirmative. This indicates that more girls considered themselves scientists at the end of the year than at the middle or beginning of the school year. The intervention could have impacted these results, since all students had participated in both the hands-on and career/role model interventions by the final survey point. These activities encouraged girls to interact with "real" scientists and to practice science themselves through hands-on experiments. When combined, these activities could have allowed more girls to see themselves as scientists, as people who experiment and discover things. An interesting response that captures the essence of the intervention was, "No, but maybe someday…"

6.4 Interview Synthesis

Twenty-four interviews were conducted at the end of the school year. All interviewees were girls who had participated in the science club intervention program. It was hoped that post-interview data would be a richer source of information than the paper based post-survey. Unfortunately, this was not the case. The girls did not provide information that would enlighten some of their previous answers to survey questions. However, it was determined that cluster analysis by the teachers and researcher would provide the best synthesis of the interview data, and a synthesis of that data follows.

The questions that drew the most interesting responses were those related to being in the club, positive and negative science experiences, and perceptions of science and scientists. We found that the main reasons for joining the club were related to enjoyment of science and having fun with science. Eighteen out of twenty-four girls (75%) responded with answers related to enjoyment of science. There appeared to be a predisposition to enjoyment of science among the girls who joined. We also found that girls remembered specific lessons and activities when asked what they learned in the club. Sixteen out of twenty-four girls (67%) described specific lab activities or field trips that they participated in as something that they learned.

When asked about positive science experiences, the responses were more variable. Although five out of twenty-four girls (21%) listed good grades as a positive experience, almost as many girls (17%) could not think of a positive science experience. Another group of five girls (21%) listed an experiment or field trip as a positive experience involving science. When asked about negative science experiences, eleven girls (46%) could not think of a negative experience. This is not surprising, as we would expect that girls participating in the science club would have general positive science associations. Six out of twenty-four (25%) recalled a test or bad grade as a negative science experience, with dissecting taking place as a close runner-up at 17%.

Turning to the more philosophical question of "what is science," the responses were surprisingly concrete. Nine out of twenty-four girls (38%) gave a standard definition of "study of everything." When asked how they formed that definition, most of the girls said they learned it in school. Five girls (21%) offered more philosophical answers involving learning about the world. These answers were less consistent and included, "I think it's people wanting to know things but they're not sure how to do it, so they use many different experiments until they come up with the right cure and the right problem solving." Another example was, "It's learning about your world that you live in. It's about mechanical things but it's more about trying to explain everything in your world." More girls seemed to acquire their definitions of science from school sources rather than sources outside the school, which parallels results found through survey analysis.

When asked "what do scientists do," eight girls (33%) described the everyday activities of scientists including experimenting, studying, and researching. Seven girls (29%) viewed scientists as creating new medicines and finding cures to diseases including cancer. Four girls (17%) described scientists sharing information such as through news reports and teaching. Altogether, the girls viewed scientists positively, as evidenced by their answers reflecting no negative associations. As with the other questions, the positive associations with scientists are not surprising since the girls joined the club due to their interest in science. These positive associations also mirror results found in analysis of the survey data, as previously mentioned.

6.5 Integration of Results Across Methodologies

The TOSRA data provided a solid foundation on which to build the qualitative portion of the study. From the TOSRA data, we learned that attitudes toward science decreased for students in grades seven and eight combined, but that seventh grade attitudes when looked at separately showed an increase over time. This finding is the opposite of previous studies (Canon and Simpson, 1985, Simpson and Oliver, 1990) in which attitudes in both grade levels dropped over time. We also learned that girls who self-selected to participate in the science club for girls did not have higher attitudes at the beginning, middle, and end of the year than girls who chose not to participate. Additionally, we found that the intervention did not maintain or increase girls' positive attitudes toward science. When looking at grade level comparisons, we did not find that seventh grade attitudes changed more than eighth grade attitudes as was expected. Rather, grade eight attitudes changed more dramatically than grade seven attitudes over the course of the school year.

With this base of information, we then turned to looking at the survey data. The data for these surveys were pooled across grade levels, since no differences in responses were observed when cluster analysis was used to sort the data into like categories. The same categories emerged for grades seven and eight, with a few exceptions in the "other" categories for each question. The results of the survey analysis indicate that the perspectives of girls in grades seven and eight were similar at all three time points when data was collected. This qualitative data did not prove useful in elucidating differences between grade levels, but it was useful in looking at trends in responses over time.

In the surveys, girls consistently viewed scientists with positive attitudes. Scientists were people who improved the world and shared their discoveries through reporting and teaching. However, when we look at the TOSRA subscale Normality of Scientists, we see that those not in the club in grade seven had more positive attitudes toward Normality of Scientists than those in the club. The opposite was true for those in grade eight; girls in the science club had higher scores on this scale than their peers who did not participate. We did not observe the same trend in the survey responses, as they remained consistent throughout the school year.

Survey data also did not reflect the results observed in the Leisure Interest in Science and Enjoyment of Science Lessons TOSRA subscales. These two scales showed significant differences between grades seven and eight, but the survey data did not show differences between grade levels. It is possible that the survey questions related to these two subscales were not detailed enough to elicit differing responses between grade levels. These questions were "What do you like to do for fun; why did you join the science club; and please tell us about a positive experience you have had involving science." It is also possible that although attitudes were statistically different on these two subscales, the qualitative data produced a different conclusion due to its open-ended methodology. The survey questions allowed girls to express their thoughts rather than rate items on a Likert scale. In future studies, the questions could be more specific to better match the TOSRA instrument statements and provide richer data for comparison. Or, alternatively, a more qualitative approach could be taken with more in-depth interviews over time to delve further into girls' thoughts about their interest in science and their enjoyment of science activities.

Although the interviews conducted at the end of the year did not provide new insight, the data validated what was found in the survey analysis. Girls again reported that they joined the club because they liked science and wanted to have fun doing science. They also corroborated survey analysis by recalling specific lessons and activities when asked what they learned from participating in the intervention program. One difference between the survey data and interview data was found in responses to describing a positive science experience. More girls could not think of a positive experience during the interviews than when they filled out the surveys. Those who listed positive experiences validated the survey data by mentioning good grades, experiments, and field trips. The question about negative science experiences also validated the survey data, with many girls not being able to describe a negative experience. Those who could think of something negative again thought of bad grades and dissecting animals.

The "what is science" interview question elicited somewhat more interesting responses than the survey responses. Although a large percentage offered the standard definitions seen in the surveys, more girls gave reflective and descriptive answers to this question during the interviews. A difference was also seen in responses to "what do scientists do," in that the idea of scientists improving the world through creation of medicines and treatment of disease was more common during the interviews than in the surveys. A new idea about scientists sharing information through reports and teaching also emerged during the interviews. It is unclear what triggered this new idea, but it is interesting to see the depth of some of the responses changing over time. Some answers were more philosophical, more sophisticated during the interviews. This could be due to maturation of the girls or to the free flowing nature of an interview dialogue.

As we consider the results from each method used in this study, it is clear that the quantitative data yielded defensible results of attitudinal change over time between girls and boys and between grade levels. We are able to look at each subscale within the TOSRA test and determine in what areas significant changes occurred during the course of a school year. With this key information in mind, we can look at the qualitative data collected through the surveys and interviews to give us a greater understanding of what was occurring amongst the girls who participated in the science club intervention program. Results from the qualitative analysis suggest that girls' motivations remain reasonably consistent during the course of a school year. Although some nuances appeared over time in response to specific questions, when taken as a whole the responses did not show much variation over time. This leads us to ask how we could better uncover factors that influence attitudes toward science over time. The conclusion to this chapter and Chapter 7 will describe some of the ways in which this could be accomplished through further study.

6.6 Social Construction of Knowledge Within the Study

This study took place within our socially constructed society, and within this society we implemented a science club intervention program with corresponding metrics to determine factors that influence girls' attitudes toward science. The development of the girls during the school year was embedded in the social construction of knowledge within the club and within the greater school environment. We can look at the results from the study and reflect upon the various roles of context, experience, and self in the development of the girls as evidenced in their responses (Dewey, 1933; Vygotsky, 1978; Kagan, 1984; Rogoff and Gardner, 1984, 1999; Rogoff, 1995; Wertsch et al., 1995; Kuhn, 1996; Rogoff, 2003; Fosnot, 2005).

The context of the study included cultural norms, the social environment, the learning situation, and many other factors. We saw that grade level influenced attitudes toward science, as did teachers, television and other media. The cultural norms that expect girls to be good in school came through as girls talked about tests and grades as influential factors in their learning. We also observed that the social environment was important to many girls; they wanted to be in the club to be with friends and to have fun. The club when viewed as a learning situation was important to girls, as they recalled specific activities within the club environment that they really enjoyed and also recalled activities that they thought of as negative science experiences. The greater school context, specifically in the form of high stakes tests, was seen to have a very influential impact on attitudes toward science and toward school in general. Clearly, the context in which this study occurred influenced girls' development as seen in their responses during the course of the school year.

The shared social experience of the club provided an environment for both individual and collective learning experiences. A few girls reflected on their individual experiences of learning science outside of school during nature walks and spending time outdoors. Most of the girls, however, focused more on collective learning experiences which included activities that were part of the club such as field trips and science experiments. They saw themselves as part of the club community, part of a group. A community as defined by Rogoff is a group of people "who have some common and continuing organization, values, understanding, history, and practices" (Rogoff, 2003, p. 80). The girls in the club were part of a continuing organization and participated for similar reasons including "to learn more science" and "to have fun." There was very little attrition in club membership during the school year, but rather there was an increase in the number of students involved as the year progressed. The club drew girls into its community, and once they were there they did not want to leave.

The teachers who helped with the club were seen as experts, as were the scientist role models who were invited to give talks about their research. The function of these adults was to “lead the learner toward an understanding of the new information” (Rogoff and Gardner, 1984, 1999). The teachers helped lead girls through the hands-on activities, whereas the scientists shared their “scientific knowledge” with the girls through their presentations and question and answer sessions. The girls embraced this ideology and overall had very favorable attitudes toward both the science teachers and the scientific experts. This is not surprising, as we would expect adolescent girls to be in early stages of epistemological development during which they would see adults as authorities (Perry, 1970, Belenky et al., 1986, Baxter Magolda, 1992, King and Kitchener, 2002). The adults were respected as guides that led the girls to knowledge and understanding.

These adults also contributed to the girls’ development of voice. Voice is a critical piece of girls’ development into women (Gilligan, 1982, 1993, Belenky et al., 1986, Brown and Gilligan, 1992). “Voice is central to our way of working—our channel of connection, a pathway that brings the inner psychic world of feelings and thoughts out into the open air of relationship where it can be found by oneself and by other people” (Brown and Gilligan, 1992, p. 20). Voice is a girl’s way of connecting with both herself and with others around her to make sense of the world. The girls in the club were able to listen to, dialogue with, and connect with the female scientists as they developed their own inner voice. They were also able to connect with each other within the safety of the all-girls club environment where women’s voices, and women’s voices alone, were heard.

To determine the role of self within this study, we can look at what stage of epistemological development we expected the girls to function and then see if their responses match that expectation. We expected that girls would look at authorities as omniscient (Perry, 1970), and indeed this was seen in their high respect for the teachers and scientists as well as their fear of bad test grades and other academic "failures" such as experiments "gone wrong."

Viewing the study through the lens of social construction of knowledge allows us to see how context, experience and self shape the learning process. We can see how the girls' construction of knowledge influenced their interactions within the science club intervention program. They participated in the club as a social experience—to be with other girls of similar backgrounds and interests. They also participated to learn something about science, and they respected the teachers and scientists who brought them to this knowledge. The girls looked to the adults for scientific knowledge, and they looked to each other for support within the social structure of the school and of the club. The club provided a safe, girls-only environment where girls could dialogue with each other and with female role models (teachers, scientists) as they developed along their epistemological paths.

6.7 Conclusion

We set out to determine if a simple intervention program could have an impact on girls during their middle school years. We attempted to sort out specific factors that influenced girls' attitudes toward science by asking questions and measuring their attitudes through both qualitative and quantitative methods. Ideally, we would have found that the intervention program impacted the girls' attitudes in a positive way, and this knowledge could inform our future efforts at implementing intervention programs both in science and in other areas. What we learned, however, showed us that the complex environment of the school and the greater context of the girls' experience most likely influenced them more than the intervention program itself.

The study explored if attitudes toward science changed over time during grades seven and eight. Specifically, we looked into whether there were differences between attitudes for students participating in the intervention program versus those not participating in the intervention program. We expected that girls who self-selected to participate in the intervention would have higher attitudes throughout the year than girls who chose not to participate. We also expected that the intervention would maintain or increase girls' positive attitudes toward science. Neither of these outcomes was observed in the students.

The main premise, therefore, that intervention in the form of a science club for girls would positively impact girls' attitudes toward science, was not supported through this study. This does not mean that the science club did not impact the girls' attitudes, but rather that there was no statistically significant difference in girls' attitudes over time for those who chose to participate in the intervention versus those that did not.

The qualitative portion of the study provided insight into factors that influenced how girls learn science and what influences their attitudes. The most influential factors in girls learning were teachers, television, and newspapers/magazines. Attitudes were impacted by teachers, grades, and other school related factors. The surveys indicated that girls' impressions of themselves as scientists improved during the school year, and although this cannot be directly attributed to the intervention, it is possible that the female scientist guest speakers influenced the girls' impressions.

The interviews at the end of the school year indicated that most girls who participated in the intervention did so because they had a predisposition for enjoying science. These girls generally felt good about science because of good grades, fun science experiments, and enrichment activities such as field trips. The girls recalled positive science experiences such as specific lab activities when asked to reflect on what they learned through the intervention program. They had a hard time recalling negative science experiences, and those that did listed things like dissecting animals and getting bad grades, neither of which were part of the intervention program. These negative experiences were from formal class instruction.

The interviews also brought out standard definitions of science such as the study of everything, indicating that the girls' definitions of science may have been formed at school rather than at home or through leisure activities. The girls viewed scientists as improving the world through the search for new medicines and cures for disease, or alternatively as people who shared information about science through news reports and teaching. Overall, impressions of scientists were positive throughout the school year.

Many factors outside the scope of the study could have impacted the results. It is very difficult for an intervention program to gain ground against forces within the school environment that shape student learning and attitudes every day. Standardized tests, classroom environment and expectations, teachers, parents, and many other variables impact student attitudes toward science and toward learning in general. It is difficult to discern the effects of an intervention program given the other factors influencing students. We can evaluate specific attitudes of students, but it is difficult to determine what is causing the shifts over time such as those that were seen in this study.

We could validate the results by conducting another study at the same school with a different cohort of students to determine if the patterns that were seen are repeated with different groups of students during different time periods. Future research could also include implementing the pre, mid, and post-surveys with the girls who chose not to participate in the intervention to determine if their responses differed from those who participated. We could explore gender differences by adding boys to the qualitative portion of the study as a comparison to girls. Opportunities to probe further into the differences between genders are prevalent within future studies modeled after this one. This research could lead to intervention programs that better meet the needs of teenagers, both boys and girls, by studying how they perceive science and the factors that impact their attitudes toward science. If we can determine the factors that are most likely to positively influence attitudes toward science, then we can develop programs that integrate those factors as students move from middle school to high school and beyond.

CHAPTER 7

IMPLICATIONS

7.1 How This Study Informs the Field

At the beginning of this exploration, we asked the question, how can we get inside the teenage girl's mind to figure out what influences her learning? If we find these answers, how can we use this knowledge to help girls grow, develop, and learn? We used a combination of methods and approaches to try to delve into the thoughts of a group of girls who participated in a science intervention program. What did we learn? A lot of factors influence girls' learning. The girls we came to know through this study told us that their science learning was influenced mostly by teachers, television, newspapers, and magazines. As expected, the school environment, with its rigorous grading and testing schemes, was stifling to the girls and contributed to their negative feelings about science learning. Poor grades, coupled with bad or mean teachers, had a negative impact on girls' learning. Their friends were less influential than we expected, although communicating with their friends through in-person, phone, and electronic communication were described as being important to them. The girls did not specifically link their feelings about science with their friends, but rather focused on how the school environment contributed to or harmed their science learning experiences.

The influence of the school environment, particularly the influence of teachers, is critically important as girls develop their conceptions of science and of the world in general. As educators, we have in our hands the capacity to positively or negatively influence students every day. The activities that we create, the feedback we give students, the attitudes we possess toward the disciplines we teach, and many other factors influence our students. Each student in turn takes something different away from the interaction with us and with his or her peers. We want to influence students, but we want to make sure that the influence is positive. What is a positive experience, and how can we judge it to be so? From the outside, we cannot determine what a positive experience might be. Each student's experience is unique, and each student is changed in a different way from that experience. Our responsibility is to provide opportunities for students to engage in activities that are meaningful to them, activities where they can control to some extent what and how they are learning. In a perfect world, students would have control over every aspect of learning, but in today's formal education system, that is not possible. This situation places a lot of responsibility on educators to provide meaningful experiences that are as open-ended as possible. These experiences allow the student to create his or her own conclusions about the activity and the subject in general.

The opportunity exists within science learning for inquiry based science, where students can form their own questions about the world around them and then design their own experiments to test their thoughts about how the world works. Every science educator should strive for this environment, where students ask the questions and adults act as guides and mentors to help the students find their own answers. The science club intervention provided this opportunity a couple of times per month during the school year, but it was fighting against the other one hundred or more hours during the month when students were sitting in regular instruction classes and doing "cookbook lab" activities with pre-determined answers. Given the minimal number of hours of interaction, how can we expect to see major differences between girls who participated in the intervention and girls who chose not to participate? Our efforts to look for these differences are not in vain, but we need to frame them in the context of the greater school environment and the broader cultural perspective so that we do not get discouraged about the minimal impacts that we see during and immediately following the intervention. We also need to continue to offer these enrichment opportunities for students, since we know that every experience has the potential to impact the individual in some way and maybe not until many years later.

7.2 Further Research Needed

Further research is underway with the original cohort of students who were involved in the intervention program. Girls who participated were invited to take part in a longitudinal follow-up study two years after the initial treatment. A survey modeled after the original post-survey was used to collect data for comparison over time. In addition to this data, a concept mapping study has been undertaken to determine what influences girls' attitudes toward science two years after the original intervention program. Concept mapping is a useful tool for organizing open-ended responses into categories. According to Trochim (1999), "Essentially, concept mapping is a structured process, focused on a topic or construct of interest, involving input from one or more participants, that produces an interpretable pictorial view (concept map) of their ideas and concepts and how these are interrelated."

Concept Systems Global (www.conceptsystems.com) was used as the framework for data collection. Background data about the girls, including their age, their current science teacher's name, and their contact information was collected through the online system. The focus prompt for the concept mapping projects was, "One thing that influences how I feel about science is…" Eight girls participated in the initial brainstorming session, and a follow-up brainstorming session drew another thirteen participants who contributed statements in response to the prompt. Reduction of statements was accomplished by the researcher in collaboration with the teachers who participated in the original intervention program. Sorting/rating is planned for the near future, and it is expected that most of the girls who participated in the brainstorming will sort and rate the statements. Results from this portion of the study will be analyzed and submitted to a peer review journal.

Considering everything that we learned within this study, our conclusions would not have been possible without the framework of a mixed methods evaluation approach. Our conclusions about the intervention program would have been drawn from isolated data, whether quantitative or qualitative, that when considered alone would paint different pictures of what was really going on with the girls involved in the study. We would not have been able to synthesize results into a coherent whole that reflects both parts and allows us to speculate beyond these individual parts.

This study has taught us that within evaluation of intervention programs, specifically those in science, we need to implement studies using mixed methodologies so that the conclusions we draw are based on more than one data source. It would be dangerous to rate the efficacy of an intervention based on only one type of measurement. For many years, advocates of mixed methods approaches to evaluation have stressed the importance of multiple measures to help determine causal relationships (Greene, 2005; Greene et al., 2005; Shadish, et al., 2002; Winship and Morgan, 1999), and this study has reinforced this idea within a specific context. We also need to implement similar studies with different cohorts to see if the same results are found.

Studying how girls learn and the factors that influence their learning presents myriad opportunities for researchers in many different fields. Within science education, we can work with groups of students to try to gain a sense not only of how girls currently learn but also how they would prefer to learn. It is often the case that girls have adopted a particular way of learning because it works within the system. For example, girls learn by studying for tests because tests are important for grades. Grades are indicators of success or failure, and the results are used to tell whether a particular girl is "smart" or "dumb." If girls are labeled as dumb, then it will be harder for them to view learning positively and therefore harder for them to learn. If they are labeled as smart, it will most likely be easier for them to learn, but this label might also come with a social stigma of "goody two shoes" or "teacher's pet," which are negative stereotypes within their peer groups. Achievement, like attitudes, is just one of the many areas in which we can study how girls approach learning.

We can also explore attitudes in other subject areas or attitudes in general to begin to understand what makes teenagers interested in some things and not others. Their attitudes and their motivation to do or not to do certain things directly affect how they interact with the world around them. The nature of this interaction impacts their achievement in school and their perspective on what they are learning. If we can probe into the cognitive and social processes that influence how adolescents interact with the world, then we can provide opportunities for enrichment that will build upon their interests and enhance their motivation to do things. As educators, our primary mission should be to discover what is going on in these adolescent minds so that we can guide their development as they move from childhood into adolescence and adulthood. Although this seems like a daunting task, it is a welcome one for any educator who truly enjoys interacting with adolescents as they discover their meaningfulness in the world.

APPENDIX A. Test of Science Related Attitudes (TOSRA)

S	1	Money spent on science is well worth spending.	SA	A	N	D	SD
N	2	Scientists usually like to go to their laboratories when they have a day off.	SA	A	N	D	SD
I	3	I would prefer to find out why something happens by doing an experiment than by being told.	SA	A	N	D	SD
A	4	I enjoy reading about things which disagree with my previous ideas	SA	A	N	D	SD
E	5	Science lessons are fun.	SA	A	N	D	SD
L	6	I would like to belong to a science club.	SA	A	N	D	SD
C	7	I would dislike being a scientist after I leave school.	SA	A	N	D	SD
S	8	Science is man's worst enemy.	SA	A	N	D	SD
N	9	Scientists are about as fit and healthy as other people.	SA	A	N	D	SD
I	10	Doing experiments is not as good as finding out information from teachers.	SA	A	N	D	SD
A	11	I dislike repeating experiments to check that I get the same results.	SA	A	N	D	SD
E	12	I dislike science lessons.	SA	A	N	D	SD
L	13	I get bored when watching science programs on TV at home.	SA	A	N	D	SD
C	14	When I leave school, I would like to work with people who make discoveries in science.	SA	A	N	D	SD
S	15	Public money spent on science in the last few years has been used wisely.	SA	A	N	D	SD
N	16	Scientists do not have enough time to spend with their families.	SA	A	N	D	SD
I	17	I would prefer to do experiments than to read about them.	SA	A	N	D	SD
A	18	I am curious about the world in which we live.	SA	A	N	D	SD
E	19	School should have more science lessons each week.	SA	A	N	D	SD
L	20	I would like to be given a science book or a piece of scientific equipment as a present.	SA	A	N	D	SD
C	21	I would dislike a job in a science laboratory after I leave school.	SA	A	N	D	SD
S	22	Scientific discoveries are doing more harm than good.	SA	A	N	D	SD
N	23	Scientists like sport as much as other people do.	SA	A	N	D	SD
I	24	I would rather agree with other people than do an experiment to find out for myself.	SA	A	N	D	SD
A	25	Finding out about new things is unimportant.	SA	A	N	D	SD
E	26	Science lessons bore me.	SA	A	N	D	SD
L	27	I dislike reading books about science during my holidays.	SA	A	N	D	SD
C	28	Working in a science laboratory would be an interesting way to earn a living.	SA	A	N	D	SD

S	29	The government should spend more money on scientific research.	SA	A	N	D	SD
N	30	Scientists are less friendly than other people.	SA	A	N	D	SD
I	31	I would prefer to do my own experiments than to find out information from a teacher.	SA	A	N	D	SD
A	32	I like to listen to people whose opinions are different from mine.	SA	A	N	D	SD
E	33	Science is one of the most interesting school subjects.	SA	A	N	D	SD
L	34	I would like to do science experiments at home.	SA	A	N	D	SD
C	35	A career in science would be dull and boring.	SA	A	N	D	SD
S	36	Too many laboratories are being built at the expense of the rest of education.	SA	A	N	D	SD
N	37	Scientists can have a normal family life.	SA	A	N	D	SD
I	38	I would rather find out about things by asking an expert than by doing an experiment.	SA	A	N	D	SD
A	39	I find it boring to hear about new ideas.	SA	A	N	D	SD
E	40	Science lessons are a waste of time.	SA	A	N	D	SD
L	41	Talking to friends about science after school would be boring.	SA	A	N	D	SD
C	42	I would like to teach science when I leave school.	SA	A	N	D	SD
S	43	Science helps to make life better.	SA	A	N	D	SD
N	44	Scientists do not care about their working conditions.	SA	A	N	D	SD
I	45	I would rather solve a problem by doing an experiment than be told the answer.	SA	A	N	D	SD
A	46	In science experiments, I like to use new methods which I have not used before.	SA	A	N	D	SD
E	47	I really enjoy going to science lessons.	SA	A	N	D	SD
L	48	I would enjoy having a job in a science laboratory during my school holidays.	SA	A	N	D	SD
C	49	A job as a scientist would be boring.	SA	A	N	D	SD
S	50	This country is spending too much money on science.	SA	A	N	D	SD
N	51	Scientists are just as interested in art and music as other people are.	SA	A	N	D	SD
I	52	It is better to ask the teacher the answer than to find it out by doing experiments.	SA	A	N	D	SD
A	53	I am unwilling to change my ideas when evidence shows that the ideas are poor.	SA	A	N	D	SD
E	54	The material covered in science lessons is uninteresting.	SA	A	N	D	SD
L	55	Listening to talk about science on the radio would be boring.	SA	A	N	D	SD
C	56	A job as a scientist would be interesting.	SA	A	N	D	SD
S	57	Science can help to make the world a better place in the future.	SA	A	N	D	SD

N	58	Few scientists are happily married.	SA	A	N	D	SD
I	59	I would prefer to do an experiment on a topic than to read about it in science magazines.	SA	A	N	D	SD
A	60	In science experiments, I report unexpected results as well as expected ones.	SA	A	N	D	SD
E	61	I look forward to science lessons.	SA	A	N	D	SD
L	62	I would enjoy visiting a science museum at the weekend.	SA	A	N	D	SD
C	63	I would dislike becoming a scientist because it needs too much education.	SA	A	N	D	SD
S	64	Money used on scientific projects is wasted.	SA	A	N	D	SD
N	65	If you met a scientist, he would probably look like anyone else you might meet.	SA	A	N	D	SD
I	66	It is better to be told scientific facts than to find them out from experiments.	SA	A	N	D	SD
A	67	I dislike listening to other people's opinions.	SA	A	N	D	SD
E	68	I would enjoy school more if there were no science lessons.	SA	A	N	D	SD
L	69	I dislike reading newspaper articles about science.	SA	A	N	D	SD
C	70	I would like to be a scientist when I leave school.	SA	A	N	D	SD

KEY TO SUBSCALES

S = Social Implications of Science
N = Normality of Scientists
I = Attitude to Scientific Inquiry
A = Adoption of Scientific Attitudes
E = Enjoyment of Science Lessons
L = Leisure Interest in Science
C = Career Interest in Science

APPENDIX B. Scoring Instrument for TOSRA Test

S	1	Money spent on science is well worth spending.	5	4	3	2	1
N	2	Scientists usually like to go to their laboratories when they have a day off.	1	2	3	4	5
I	3	I would prefer to find out why something happens by doing an experiment than by being told.	5	4	3	2	1
A	4	I enjoy reading about things which disagree with my previous ideas	5	4	3	2	1
E	5	Science lessons are fun.	5	4	3	2	1
L	6	I would like to belong to a science club.	5	4	3	2	1
C	7	I would dislike being a scientist after I leave school.	1	2	3	4	5
S	8	Science is man's worst enemy.	1	2	3	4	5
N	9	Scientists are about as fit and healthy as other people.	5	4	3	2	1
I	10	Doing experiments is not as good as finding out information from teachers.	1	2	3	4	5
A	11	I dislike repeating experiments to check that I get the same results.	1	2	3	4	5
E	12	I dislike science lessons.	1	2	3	4	5
L	13	I get bored when watching science programs on TV at home.	1	2	3	4	5
C	14	When I leave school, I would like to work with people who make discoveries in science.	5	4	3	2	1
S	15	Public money spent on science in the last few years has been used wisely.	5	4	3	2	1
N	16	Scientists do not have enough time to spend with their families.	1	2	3	4	5
I	17	I would prefer to do experiments than to read about them.	5	4	3	2	1
A	18	I am curious about the world in which we live.	5	4	3	2	1
E	19	School should have more science lessons each week.	5	4	3	2	1
L	20	I would like to be given a science book or a piece of scientific equipment as a present.	5	4	3	2	1
C	21	I would dislike a job in a science laboratory after I leave school.	1	2	3	4	5
S	22	Scientific discoveries are doing more harm than good.	1	2	3	4	5
N	23	Scientists like sport as much as other people do.	5	4	3	2	1
I	24	I would rather agree with other people than do an experiment to find out for myself.	1	2	3	4	5
A	25	Finding out about new things is unimportant.	1	2	3	4	5
E	26	Science lessons bore me.	1	2	3	4	5
L	27	I dislike reading books about science during my holidays.	1	2	3	4	5
C	28	Working in a science laboratory would be an interesting way to earn a living.	5	4	3	2	1
S	29	The government should spend more money on scientific	5	4	3	2	1

		research.					
N	30	Scientists are less friendly than other people.	1	2	3	4	5
I	31	I would prefer to do my own experiments than to find out information from a teacher.	5	4	3	2	1
A	32	I like to listen to people whose opinions are different from mine.	5	4	3	2	1
E	33	Science is one of the most interesting school subjects.	5	4	3	2	1
L	34	I would like to do science experiments at home.	5	4	3	2	1
C	35	A career in science would be dull and boring.	1	2	3	4	5
S	36	Too many laboratories are being built at the expense of the rest of education.	1	2	3	4	5
N	37	Scientists can have a normal family life.	5	4	3	2	1
I	38	I would rather find out about things by asking an expert than by doing an experiment.	1	2	3	4	5
A	39	I find it boring to hear about new ideas.	1	2	3	4	5
E	40	Science lessons are a waste of time.	1	2	3	4	5
L	41	Talking to friends about science after school would be boring.	1	2	3	4	5
C	42	I would like to teach science when I leave school.	5	4	3	2	1
S	43	Science helps to make life better.	5	4	3	2	1
N	44	Scientists do not care about their working conditions.	1	2	3	4	5
I	45	I would rather solve a problem by doing an experiment than be told the answer.	5	4	3	2	1
A	46	In science experiments, I like to use new methods which I have not used before.	5	4	3	2	1
E	47	I really enjoy going to science lessons.	5	4	3	2	1
L	48	I would enjoy having a job in a science laboratory during my school holidays.	5	4	3	2	1
C	49	A job as a scientist would be boring.	1	2	3	4	5
S	50	This country is spending too much money on science.	1	2	3	4	5
N	51	Scientists are just as interested in art and music as other people are.	5	4	3	2	1
I	52	It is better to ask the teacher the answer than to find it out by doing experiments.	1	2	3	4	5
A	53	I am unwilling to change my ideas when evidence shows that the ideas are poor.	1	2	3	4	5
E	54	The material covered in science lessons is uninteresting.	1	2	3	4	5
L	55	Listening to talk about science on the radio would be boring.	1	2	3	4	5
C	56	A job as a scientist would be interesting.	5	4	3	2	1
S	57	Science can help to make the world a better place in the future.	5	4	3	2	1
N	58	Few scientists are happily married.	1	2	3	4	5

I	59	I would prefer to do an experiment on a topic than to read about it in science magazines.	5	4	3	2	1
A	60	In science experiments, I report unexpected results as well as expected ones.	5	4	3	2	1
E	61	I look forward to science lessons.	5	4	3	2	1
L	62	I would enjoy visiting a science museum at the weekend.	5	4	3	2	1
C	63	I would dislike becoming a scientist because it needs too much education.	1	2	3	4	5
S	64	Money used on scientific projects is wasted.	1	2	3	4	5
N	65	If you met a scientist, he would probably look like anyone else you might meet.	5	4	3	2	1
I	66	It is better to be told scientific facts than to find them out from experiments.	1	2	3	4	5
A	67	I dislike listening to other people's opinions.	1	2	3	4	5
E	68	I would enjoy school more if there were no science lessons.	1	2	3	4	5
L	69	I dislike reading newspaper articles about science.	1	2	3	4	5
C	70	I would like to be a scientist when I leave school.	5	4	3	2	1

Note: Scores are additive for each of the seven subscales, with a total possible score of 50.0 on each subscale.

APPENDIX C. Pre, Mid, and Post-surveys for Science Club Members

PRE-SURVEY

1. Your favorite subject: ___________________________ Why?
2. Least favorite subject: ____________________________Why?
3. What extracurricular activities do you participate in (sports, music, drama club, student council, etc.)?
4. What do you like to do for fun?
5. What kind of career are you considering?
6. Are you planning to attend college? YES NO
7. Why did you join the Tri-Sci Club?
8. What would you like to learn from being in this club?
9. Please tell us about a positive experience you have had involving science.
10. Please tell us about a negative experience you have had involving science.
11. Do you believe you are good at learning about science? YES NO
12. Does your teacher help you learn about science? YES NO
13. Does your science class help you learn about science? YES NO
14. Does your family help you learn about science? YES NO
15. Do your friends help you learn about science? YES NO
16. Does TV help you learn about science? YES NO
17. Does the Internet help you learn about science? YES NO
18. Do newspapers or magazines help you learn about science? YES NO
19. What is science?
20. Please describe what a scientist does.
21. Do you consider yourself a scientist? YES NO

MID-SURVEY

1. Your favorite subject: ___________________________ Why?
2. Least favorite subject: ____________________________Why?
3. What extracurricular activities do you participate in (sports, music, drama club, student council, etc.)?
4. What do you like to do for fun?
5. What kind of career are you considering?
6. Are you planning to attend college? YES NO
7. Why did you join the Tri-Sci Club?
8. What would you like to learn from being in this club?
9. Please tell us about a positive experience you have had involving science.
10. Please tell us about a negative experience you have had involving science.
11. Do you believe you are good at learning about science? YES NO
12. Does your teacher help you learn about science? YES NO
13. Does your science class help you learn about science? YES NO
14. Does your family help you learn about science? YES NO
15. Do your friends help you learn about science? YES NO

16. Does TV help you learn about science? YES   NO
17. Does the Internet help you learn about science? YES   NO
18. Do newspapers or magazines help you learn about science? YES   NO
19. What is science?
20. Please describe what a scientist does.
21. Do you consider yourself a scientist? YES   NO

POST-SURVEY

1. Your favorite subject: ___________________________ Why?
2. Least favorite subject: ____________________________Why?
3. What extracurricular activities do you participate in (sports, music, drama club, student council, etc.)?
4. What do you like to do for fun?
5. What kind of career are you considering?
6. Are you planning to attend college? YES   NO
7. Why did you join the Tri-Sci Club?
8. What did you learn from being in this club?
9. Please tell us about a positive experience you have had involving science.
10. Please tell us about a negative experience you have had involving science.
11. Do you believe you are good at learning about science? YES   NO
12. Does your teacher help you learn about science? YES   NO
13. Does your science class help you learn about science? YES   NO
14. Does your family help you learn about science? YES   NO
15. Do your friends help you learn about science? YES   NO
16. Does TV help you learn about science? YES   NO
17. Does the Internet help you learn about science? YES   NO
18. Do newspapers or magazines help you learn about science? YES   NO
19. What is science?
20. Please describe what a scientist does.
21. Do you consider yourself a scientist? YES   NO

APPENDIX D. Post-interview for Science Club Members

Intro: During the school year, you answered some questions for me about science. I've looked at what you said and I'd like to ask you a few more questions so I can better understand what you're thinking about science. Are you ready to get started?

1. What do you want to do when you grow up? Why?
2. Are you planning to attend college? YES NO
3. If yes, what made you interested in going to college?
4. Can you tell me a little more about why you joined the science club?
5. What did you learn from being in the club?
6. Can you tell me about a positive experience you've had in science?
7. Can you tell me about a negative experience you've had in science?
8. Do you think you are good at learning about science? What makes you feel that way?
9. Do teachers help you learn about science? How so?
10. Did your science class help you learn about science? Why/why not?
11. Does your family help you learn about science? How so?
12. Do your friends help you learn about science? How so?
13. Does TV help you learn about science? Can you give me an example?
14. Does the Internet help you learn about science? Can you give me an example?
15. Do newspapers or magazines help you learn about science? Can you give me an example?
16. What is science?
17. What do scientists do? Where does your impression of scientists come from?
18. Do you know anyone who is a scientist? If so, what does he/she do?
19. Do you consider yourself a scientist? Why/why not?
20. Is there anything else you'd like to share with me today?

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