Science Career Interests Among High School Females One Year after Participation in a Summer Science Program

by

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ABSTRACT

A residential summer program, the New Experiences for Women in Science and Technology (Newton) Academy, was developed to encourage high school females interest in the physical sciences and engineering. The goal of the Newton Academy was to increase and/or maintain interest and participation in the physical sciences among high school females. This study, part of a larger evaluation of the academy (Phillips, 2000), reports the results of a follow-up of the 1998 Newton Academy participants one year after participation in the academy. It focuses on the participants interests in the physical sciences and related careers as measured by the Strong Interest Inventory (Harmon, Hansen, Borgen, & Hammer, 1994) before and one year after participation. Results from participant interviews conducted to further illuminate the findings from the quantitative data are also presented.

INTRODUCTION

Despite efforts over the last 25 years, females are still not participating in the sciences, particularly the physical sciences, at the same level as males. According to data from the National Science Foundation (National Science Foundation {NSF}, 1999), 22% of females enroll in high school physics, compared to 27% of males. In 1996, women earned 47% of bachelor s degrees in science and engineering fields, including social sciences; yet, when this figure is examined by science type, one discovers that women earned only 37% of physical science degrees and only 18% of engineering degrees (NSF, 2000).

Student Interest in Science

Much of the research on student interest in science has documented declining interest over time. Using the multi-dimensional science interest instrument developed by Simpson and Troost (1982), Simpson and Oliver (1985; 1990) found that attitude toward science becomes less positive throughout grades six through ten and throughout each school year in those grades. The attitudes were strongly positive toward science at the beginning of sixth grade and changed to a neutral attitude at the end of tenth grade. They determined that school factors, such as the classroom activities and the teacher, more strongly influenced attitude toward science than factors attributed to the individual or to parental and home influences. The same instrument was used to investigate the correlation between peer and individual attitudes toward science over time (Talton & Simpson, 1985). Talton and Simpson determined that the strength of the relationship between peer and individual attitudes increased significantly over grades six through eight and peaked in grade nine. Further, the strength of the relationship increased during each school year; as the year progressed, individual attitudes became more like peer attitudes. Correlations ranged from 0.37 at the beginning of sixth grade to 0.68 at the end of ninth grade.

Similar decreases in student interest across grades in science were found when studying students in grades two, five, eight, and eleven using a researcher-developed instrument (Moffat, Piburn, Sidlik, Baker, & Trammel, 1992). However, different patterns in interest changes were found in a research study involving mostly African-American urban seventh grade students (Hill, Atwater, & Wiggins, 1995). In that study, which used the Simpson-Troost Attitude Instrument (1982), over 50% of the students either maintained a positive attitude toward science or changed to a positive attitude toward science between mid-year and the end of the school year. These changing attitudes appeared to be related to the students attitudes toward their science teachers.

The second focus of attitude measures has been to document gender differences in attitude toward science. Overwhelmingly, the results have shown that males attitudes were significantly more positive than females attitudes (Catsambis, 1995; Colley, Comber, & Hargreaves, 1994; Moffat et al., 1992; Simpson & Oliver, 1985, 1990; Weinburgh, 1995). In a study focusing on middle school students using the National Educational Longitudinal Study of 1988 (NELS-88) data for eighth grade students, Catsambis (1995) found that females attitudes toward science were significantly more negative than males, despite achieving higher grades and scoring similarly on achievement tests. For all three racial groups studied (white, African-American, and Latina/o), males indicated that they looked forward to science class more than females did, and males more than females thought science would be useful to them in the future. Additionally, significantly more males than females participated in mathematics and science extracurricular activities.

Reflecting the decrease in student interest over the course of the school year mentioned above, Jovanovic and Dreves (1998) determined that fifth through eighth grade girls interest in science declined from the beginning to the end of the school year. This finding was also true for seventh and eighth grade boys but not for the younger boys. In this study, interest in science was determined by a 4-item scale asking questions such as How much do you like science? and How useful do you think science will be for what you do after you finish school?

More positive attitudes for males have not always been seen when the populations have been subdivided further. For example, Greenfield (1997) found that elementary school girls liked science more than similar-aged boys, as measured by the Simpson-Troost Instrument (1982). Both groups interest levels declined during intermediate school, but boys interests rose again during high school and girls did not, ending in the predicted result of significantly higher interests among males. Similar drops in female interests in late elementary school were noted by Moffat and her colleagues (1992). In her meta-analysis of the literature on gender differences in student attitudes toward science, Weinburgh (1995) found that high performance girls showed more positive attitudes than did all levels of boys.

Gender Differences in Interest in Science Careers

In 1997, women represented 46% of the United States workforce, yet only 23% of the science and engineering labor force (NSF, 2000). As in the high school course taking and college major patterns, women are participating significantly more in biological sciences careers than in physical sciences careers. Thirty-six percent of employed biological scientists are women, while women comprise only 9.7% of physicists and 6% of electrical and mechanical engineers (NSF, 2000).

Gender differences in mathematics and science career interests manifest themselves at an early age. Research involving elementary school students indicates that these students hold more stereotypical views of gender appropriateness for careers than do secondary school students (Miller & Budd, 1999). In a study of gifted fifth and sixth grade students, Jensen and McMullen (1994) determined that gender did not significantly correlate with interest in mathematics or science careers for fifth graders, but did for sixth graders. Relationships between these variables were not explored beyond simple correlation.

Despite holding less stereotypical views about which careers are appropriate for females and males, secondary students still exhibit significant gender differences in their preferences for scientific careers, with males expressing higher interest (Miller & Budd, 1999). In the study by Catsambis (1995), more eighth grade males than females aspired to science careers, with a high of 8.5% for white males and a low of 2.4% for African-American females. These low levels of science career interest are particularly disturbing because, for females, interest in science in school and continued science course taking has been found to be closely tied to perceived usefulness in future career choices (Moffat et al., 1992; Riesz, McNabb, & Stephen, 1997).

The Strong Interest Inventory (SII) has been used for over 70 years to measure career interests in adolescents and adults (Harmon et al., 1994). The results from the 1994 version of the SII are divided into scores on four Personal Style Preferences (PSP), six General Occupational Themes (GOT), 25 Basic Interest Scales (BIS), and 109 Occupational Scales (OS), moving from a description of the individual s more general career interests to measures of interests in specific occupational categories. Significant gender differences exist on the SII, most notably that males score higher than females on the GOTs that correspond to science and engineering careers, the Realistic and the Investigative themes (Harmon et al., 1994; Kaufman & McLean, 1998).

Researchers have investigated the relationships of career interests as measured by the SII to various other variables, primarily for the purpose of improving career counseling. Some of the findings relevant to this study include the positive relationship between IQ and the Investigative GOT score (Kaufman & McLean, 1998), and the weak relationship between mathematics and science interests and objectively measured mathematics and science abilities (White, 1998). A stronger relationship between self-estimated mathematics ability and mathematics interests (as measured by the Mathematics BIS) was determined (White, 1998).

One of the most common variables researchers have studied in relation to career interests in mathematics and science is self-efficacy, or the belief of an individual that they can perform a given task. Findings include the fact that larger numbers of women than men express lower self-efficacy in Realistic and Investigative related tasks (Lenox & Subich, 1994) and that the threshold that appears to be present in the relationship between self-efficacy and Realistic and Investigative interests requires at least a medium amount of self-efficacy in these areas before interest begins to increase (Lenox & Subich, 1994). In a study of entering college freshmen, Lapan, Boggs, and Morrill (1989) determined that mathematics self-efficacy and high school mathematics preparation mediated gender differences on the Realistic and Investigative GOTs. As a follow-up to the 1989 study, Lapan, Shaughnessy, and Boggs (1996) determined the college majors of the original study participants when they were juniors in college. Lapan, Shaughnessy and Boggs found that intended college major as a freshman significantly predicted junior college major for those choosing mathematics/science careers. Therefore, the decision to enter a math/science major was in large part a function of preexisting efficacy and vocational interest patterns (p. 288). In their study, women took fewer high school mathematics classes, received lower ACT mathematics scores, and had lower mathematics self-efficacy beliefs. Mathematics self-efficacy strongly predicted Investigative GOT efficacy and vocational interests in mathematics. Higher Investigative GOT efficacy ratings were related to greater interest in mathematics and choice of math/science major as a freshman and subsequently as a junior.

In addition to the insight gained from quantitative measures of career interests such as the SII, valuable information about gender difference in choosing science careers can be gained from qualitative studies. Davis (1999) conducted a study to examine the experiences of three successful women scientists and to gain an understanding of why some women choose science and continue to pursue careers in science. By looking at these three cases, she determined that the questioning and problem solving of science was fascinating to these women and that teachers had played critical roles in their identity development and career selection as scientists. For these women, it was very important that they had been given opportunities to design and conduct scientific inquiry and that their teachers had taken their ideas seriously.

METHODS

Description of the 1998 Newton Summer Academy

In order to understand this research study involving the participants of the Newton Academy, a more rich description of the academy is warranted. The goal of the 10-day, residential academy was to be achieved through the following objectives: (a) provide hands-on, integrated physics, engineering, and mathematics experiences; (b) provide opportunities for those students to interact with women scientists who may serve as career role models; and (c) provide peer groups of female students who are interested in the physical sciences.

The primary activity of the Newton Academy was the construction of a polymer ball factory to produce toy bouncing balls. To prepare for this task, the students participated in eight three-hour lessons. They first learned about polymer chemistry in a chemistry lab where they made polymers with different materials and with different concentrations of materials. They then conducted waste analysis of their polymer components using absorption spectroscopy. They studied engineering design principles assembling small machines that performed specific tasks such as moving an object on a conveyor belt using Fisher Technicks construction kits. Two sessions were conducted on electricity, including activities on series and parallel electric circuits; measurement of voltage, current and power; and assembling a simple motor. As a group, the participants produced polymer balls with differing concentrations of borax solution and glue gel, and then used a mathematical optimization program to determine the solution producing the ball with the highest bounce. Students conducted a reverse engineering task by disassembling copier machines and typewriters to examine the designs and parts used in these types of technology. Some of the parts were saved for reuse in building their own factories. To observe other types of manufacturing processes, the participants toured a commercial chemical plant and programmed manufacturing robots at a university engineering manufacturing laboratory.

Following these sessions, student groups designed their own factories on paper. Teaching assistants and industrial technology teachers were available for consultation. The groups made a presentation of their design to the rest of the participants and the faculty, eliciting helpful hints or criticism. Raw materials for the factories were made available through a store, and building help was provided via an industrial technology teacher operating a band saw. The participants then built their factories over a three-day period. Further details of the academy are available on the website http://www.missouri.edu/~wwwepic.

Several activities were undertaken in order to provide daily exposure to female physical science role models. Each team of students chose the name of a prominent female physicist or chemist to represent their team. Two of the academy directors were females, one a university physics professor and the other a science curriculum coordinator for the local school district. The third director was a male university industrial engineering professor. The female faculty of the academy included a chemistry professor, a chemistry teaching assistant, a mathematics professor, and two science teachers. The male faculty were comprised of two industrial technology teachers and a science teacher. The program coordinator, a female, was a former engineer and science teacher, and the program evaluator was a male university education professor. Finally, the counselors who supervised the participants in the residence halls and for evening activities were also female scientists: two chemistry graduate students, one senior physics undergraduate, and one biology graduate preparing to enter medical school.

In addition to the daily interactions with female scientists, the participants were able to meet and interact with a large group of female physical science role models at a formal reception and dinner on the eighth night of the program. At the team-building session on the first night of the program, the students wrote a list of questions that they would like to ask female scientists. These questions were compiled and given to the students prior to the reception and dinner so that they would have discussion topics for their interactions that evening. Along with their communications with individual scientists, the participants asked many questions of the dinner speaker, a female mechanical engineer who had taken a non-traditional route into the profession.

Another role model was provided by a NASA Jet Propulsion Laboratory scientist who came for a special presentation on the sixth day of the academy. She gave a technical presentation at a luncheon for the participants and then was available for informal interactions in the afternoon and led a science fiction movie night in the evening.

In addition to the many physical science careers that the students encountered in their interactions with the personnel of the academy and the guests at the formal dinner, the students also researched careers at a half-day session at the university career counseling center. They found information on multiple physical science-related careers that interested them, including education and training requirements and average salary levels. The students were exposed to medical physics careers during an evening tour of diagnostic imaging and radiation treatment facilities at a local hospital.

The Participants

Participation in the academy was voluntary and students were selected based on achieving grades of B or better in their high school mathematics and science courses and writing a short essay describing their interest in attending the academy. Thirty-eight students applied for the program, and all were accepted. Before the first day of the academy, five students indicated that they would not be attending. Due to the voluntary nature of the Newton Academy and the selection criteria applied, all of the participants were considered to be highly motivated, science-interested, female students. Thirty-two of the 33 participants completed all of the follow-up assessments administered one year after the academy was conducted.

Of the 32 participants in this study, 26 were Caucasian, four were Asian-American, and two were African-American. All were non-Hispanic. Nine of the young women were entering the 12th grade in the school year following the academy, four were entering the 11th grade, and the remaining 19 were entering the 10th grade. Prior to participation in the academy, all of the students attended junior high or high school in rural school districts. Eight of the students were from small districts (less than 2600 students enrolled K-12) and the remaining 24 students were from mid-size districts (8,000 to 15,000 students enrolled K-12).

The Strong Interest Inventory

The SII (Harmon et al., 1994), along with other assessments, was administered to the academy participants before any formal academy activities were conducted. The results of the SII were presented to the students later in the academy and interpretation assistance was provided by trained counselors. One year after the academy, follow-up assessments, including the SII, were mailed to the participants.

The SII is the career interest inventory that is most commonly used and one of the most respected in the counseling field (Harmon et al., 1994; Kaufman & McLean, 1998). The SII has been continually revised over the last 70 years to keep current with changes in the workforce, with the latest revision in 1994 (Harmon et al., 1994). The 1994 version was used in this study. The 1994 SII was normed on

18,951 adults, divided into the female General Reference Sample (GRS) (N=9,467) and the male GRS (N=9,484). The results from the SII are given to the student in a twelve-page profile.

The SII data that were of interest in this study related to the students interests in the physical sciences and related careers. Selected BISs and OSs were chosen. The BISs are reported as standard scores (M=50, SD=10). The developers of the SII consider the BISs to be subdivisions of the GOTs (Harmon et al., 1994), and group them as such on the SII profile provided to respondents. Mechanical Activities is grouped under the Realistic GOT and Science and Mathematics are grouped under the Investigative GOT. However, Lapan, McGrath, and Kaplan (1990) studied the underlying factor structure of the BISs and found that, for women, Mechanical Activities, Science, and Mathematics, loaded on a single factor, which they named Investigative. This factor structure was stable over analyses of the BISs from administrations of the SII in 1969, 1974, 1981, and 1985.

Because the Mechanical Activities, Science, and Mathematics BISs are those most closely related to the activities of the Newton Academy, the Investigative Factor as determined by Lapan, et al. (1990) was used for analysis in this study. Participant scores on this factor were determined by finding the mean of the three BIS scores included. The Investigative Factor score provides a more precise measure of physical science interest than would a combination of the Realistic and Investigative GOT scores which include interests not related to the physical sciences. For example, the Investigative GOT incorporates items relating to the Medical Science BIS, which was found, for females, to be related to a separate Medical factor by Lapan and his colleagues (1990).

Cronbach Alpha scores indicating the reliability of the Mechanical Activities, Science, and Mathematics scales are 0.938, 0.904, and 0.890, respectively, and three-to-six month test-retest reliabilities range from 0.78 to 0.92 for these three scales (Harmon et al., 1994). A variety of information attesting to the concurrent, construct, and predictive validity of the BISs is provided by Harmon and her colleagues (1994). Additionally, Schmidt, Lubinski, and Benbow (1998) have provided evidence for the construct validity of the BISs for high achieving adolescents of the SMPY. In a comparison of the data from the adolescents to that of graduate students in mathematics and science, a high degree of adolescent to adult cross-validation was displayed. Additionally, the Science and Mathematics BISs showed a high degree of covariance with anticipated occupational importance of math and physics and with preferences for science courses and tinkering activities. In another analysis of the data from the GRS, Donnay and Borgen (1996) determined that, of the three non-occupational measures on the SII (GOTs, BISs, and PSPs), the BISs are the most valid predictors of occupational group membership.

The OSs contribute the most specific information provided by the SII profile. They indicate how closely an individual s responses match with the likes and dislikes of people actually employed in and satisfied with particular occupations (Harmon et al., 1994). The 1994 SII contains information on 211

OSs, 102 pairs with separate scales for women and men and seven scales corresponding to occupations that were represented by only one gender (for example, too few male Child Care Providers could be found to provide a large enough sample to include on the SII). Each of the OSs have different minimum and maximum scores because they contain varying numbers of items, but for each, a score of 40 or above indicates that the respondent has similar interests to persons satisfactorily employed in that field. Higher scores on the OSs mean that both the repondent's interests and aversions match those of the occupational sample.

For this study, the OSs of Chemist, Engineer, Mathematician, and Physicist were selected for analysis. These occupations correspond to those related to the content targeted by the Newton Academy. Table 1 shows the three-to-six month test-retest reliability scores and the Tilton percent overlap (concurrent validity) scores for these four female OSs (Harmon et al., 1994). The Tilton percent overlap statistic is a measure of the ability of the scale to discriminate between the occupational group and the GRS. If the scale discriminates perfectly between these two samples the overlap is zero percent. If the scale does not discriminate at all and the two groups are the same, the overlap is 100 percent. The SII discriminates better for female mathematicians and physicists than for chemists or engineers.

Insert Table 1 about here

Interview Procedures

Six participants were chosen for semi-structured interviews based on the magnitude of the changes in their SII scores after one year. A composite score comprised of the Investigative Factor score and the four Occupational Scores was calculated by summing these scores. Three of the five participants whose score increased the most and three of the five participants whose scores decreased the most were randomly selected. The interviews were conducted in the participants homes and were recorded on audio tape and later transcribed for analysis.

RESULTS

The Investigative Factor and each of the OSs were analyzed using five separate Repeated Measures General Linear Model (GLM) procedures. No covariates were used, as all members of the group were assumed to be highly motivated and high-achieving (grades of B or better) in mathematics and science. The significance level for these tests was $p<0.01$, as determined by the Bonferroni correction to guard against type I error (Pedhazur, 1997). The data was not further analyzed by race/ethnicity or by grade due to the small numbers of students in some of the subpopulations.

The means and standard deviations for the pretest and the posttest for each of the SII measures are presented in Table 2. Table 3 contains the results of the GLM analysis. No significant differences were found in any of the pre- and post-test comparisons, indicating that the participants interests remained stable as a group over the one-year period.

Insert Table 2 about here

Insert Table 3 about here

When examined individually, however, some participants showed large (up to 78%) increases or decreases in their composite SII scores. Six of the students exhibiting these large increases or decreases were interviewed. The interviews were designed to look for commonalities and patterns in the participants experiences and understandings of the contribution of the Newton Summer Academy to their interests in the physical sciences and in related careers one year after participation in the program. Four themes were developed from the participants responses: Science Classroom Experiences, Interest in Hands-On Activities, Interest in Mathematics, and Career Influences.

Science Classroom Experiences

The participants whose interests increased could recall positive experiences or feelings about their academic science courses in the previous year. Although none of these courses were physical science courses (they were first or second year biology courses), the positive experiences seemed to contribute to increased interest in the physical sciences. Two of the students with decreased interest specifically recalled negative experiences with school physical (chemistry and physics) science courses in the previous year.

Interest in Hands-On Activities

All of the participants interviewed expressed a general interest in science. However, those whose interests had increased over the 12-month period indicated that their interest in science stemmed from an interest in hands-on activities, such as experiments and blowing things up, while those whose interests had decreased focused more on the knowledge aspect of science, mentioning an interest in the neat little facts of science, the problem solving, and the DNA genetics unit [and] gas laws.

Interest in Mathematics

The participants whose interest increased exhibited a level of enthusiasm for mathematics that was decidedly higher than that of the participants whose interest decreased. The former group made such comments as I love Algebra,   I love math, and I like the challenge that math presents.   The latter group seemed to view mathematics as a subject that could be tolerated, but that did not provoke interest.

One student commented that I do pretty well in all the math classes I ve taken, so It s all right I guess I m not really interested in it, I just do it It s just not something that I consider fun.

Career Influences

When asked about the effect of the Newton Academy on their interests in physical science-related careers, five of the participants interviewed reported a positive effect and the sixth participant, whose scores decreased, reported no effect. The students exhibiting a decrease in their overall interest scores indicated that Newton Academy personnel had specifically interested them in engineering careers. The students with an increase in their overall interest scores did not mention personnel, but instead credited the activities of the Academy with increasing their confidence in their physical science-related abilities. The members of this group could each also recall a specific career exposure experience during the Academy that prompted their interest in physical science careers. Two participants mentioned their trips to the career center to investigate science and engineering careers, and the other mentioned field trips to the medical physics department of a local hospital and the campus engineering manufacturing laboratory as being influential to her career decision making.

In summary, analysis of the interview data led to the following assertions: the students whose interests increased had more positive school science experiences, expressed more interest in hands-on science activities, and were more interested in mathematics than those students whose interests decreased. The participants whose interest increased could all remember a specific career-related activity from the Academy that affected their interest and two commented on the Academy s positive affect on their confidence in physical science related activities.

DISCUSSION

In this study, the summer academy participants interests in the physical sciences and related careers, when measured as a group, were extremely stable over a period of one year. This finding does not correspond with previous research by Moffat et al. (1992) and Simpson & Oliver (1985, 1990) who reported that student interest in science decreased each year of middle and secondary school. Although the population being studied was self-selected as interested in science, their SII scores did not distinguish them from the female population as a whole as being interested in physical science careers. While causality of the Newton Academy experience cannot be implied, the stability of the interest scores over a period of one year indicates that this group of students differs from other populations of female secondary students whose interest was shown to decline.

Despite their professed interest in science, the participants scores on the SII did not distinguish them as a group that was highly interested in science careers. The mean values for the Investigative Factor were 51.14 and 51.63 for the pretest and posttest, respectively. These values were within the Average Interest range for females for the Mechanical Activities, Science, and Mathematics BISs from which the Investigative Factor is derived. The Newton Academy participants pretest and posttest scores on the Chemist and Engineer OSs (35.38 and 34.72 for Chemist, 36.91 and 38.16 for Engineer) were below the score of 40 considered to represent similar interests as females employed in those occupations. The Mathematician and Physicist OS pretest and posttest scores (19.13 and 20.66 for Mathematician and 23.16 and 23.22 for Physicist) were far below the target score of 40 for similar interests. As a group, the Newton Academy participants did not express similar interests to employed physical scientists, neither before their participation in the Academy nor one year following participation. The low levels of interest in physical science careers mirror the results of Miller and Budd (1999) and Catsambis (1995).

Despite the low levels of interest in specific physical science careers, programs such as the Newton Academy may still have an impact. The variability of the individual students interest scores discussed below indicate that students of this age group are still forming their career interests. Since only approximately one quarter of high school females enroll in a high school physics course, most will not have exposure to physical science careers. Programs such as this academy are designed to provide them with different experiences to help ensure that they do not rule these careers out due to lack of information.

When examining participants interests individually, large differences emerged between the pretest and the posttest, with some participants showing large increases in interest and some participants showing large decreases. This finding indicates that interests in the physical sciences and related careers are not necessarily stable for females at the high school level. Further investigation into this finding during the interviews revealed that recent experiences in the participants lives, particularly in their school science experiences, were very influential in their current expression of interest in science and science careers. This finding corroborates the assertion by Simpson and Oliver (1985; 1990) that school factors, such as classroom activities and the teacher, more strongly influence students attitude toward science than do individual, parental, or home factors. The influence of teachers on interest in physical science careers also corresponded with the assertions made by Davis (1999) in her qualitative study of women scientists.

The students who experienced an increase in SII interest scores reported that they were more interested in mathematics than were the other students. This self-reported interest may be a reflection of mathematics self-efficacy, a variable discussed below. Mathematics aptitude is crucial to success in physical science-related careers. Although all of the Newton Academy participants were successful in school mathematics courses, this finding indicates that those who exhibit more interest in physical science careers are more likely to enjoy their mathematical experiences.

All of the Newton Academy participants were high achievers in mathematics and science courses in school. The large disparities exhibited in their SII scores for physical science-related interests provides further support for the results obtained by White (1998), who found a weak relationship between objectively measured mathematics and science abilities and mathematics and science interests. Clearly, students do not have to be interested in a subject to perform well on achievement measures.

A variable that was not measured in this study, but which emerged during the interview process was confidence, or self-efficacy. The students whose SII interest scores had increased mentioned that the Newton Academy had increased their confidence in their abilities to do physical science-related activities. This finding is similar to others who have documented the relationship between self-efficacy and interest in science and mathematics (Lapan et al., 1989; Lapan et al., 1996; Lenox & Subich, 1994; White, 1998). More recently, O Brien, Kopala, and Martinez-Pons (1999) determined a direct relationship between mathematics self-efficacy and science career interest. In their study, academic achievement was also strongly correlated with science career interest, but was completely mediated by self-efficacy.

Due to the variable nature of high school students interests, a program such as the Newton Academy has the potential to affect those interests. However, the qualitative data gathered in this study suggests that students most recent life experiences are apt to influence their interests most strongly. This finding points to the need for a long-term program as opposed to, or in addition to, a one-time, intense experience. If the participants could encounter the positive, hands-on, physical science activities multiple times over the course of a year or longer, they may show more sustained positive gains in interest.

The students who showed large positive gains in physical science interest scores indicated that they remembered a specific career-related activity from the Academy one year earlier. It is recommended that intervention programs feature more of these career-focused activities and that the instructors explicitly relate content-oriented segments to relevant physical science careers. Further investigations into the effect of similar intervention programs on females math and science self-efficacy may provide more insight into effective program designs.

REFERENCES

Catsambis, S. (1995). Gender, race, ethnicity and science education in the middle grades. Journal of Research in Science Teaching, 32(3), 243-257.

Colley, A., Comber, C., & Hargreaves, D. J. (1994). Gender effects in school subject preferences: A research note. Educational Studies, 20(1), 13-18.

Davis, K. S. (1999). Why science? Women scientists and their pathways along the road less traveled. Journal of Women and Minorities in Science and Engineering, 5, 129-153.

Donnay, D. A. C., & Borgen, F. H. (1996). Validity, Structure, and Content of the 1994 Strong Interest Inventory. Journal of Counseling Psychology, 43(3), 275-291.

Greenfield, T. A. (1997). Gender- and grade-level differences in science interest and participation. Science Education, 81, 259-276.

Harmon, L. W., Hansen, J.-I. C., Borgen, F. H., & Hammer, A. L. (1994). Strong Interest Inventory applications and technical guide. Palo Alto, CA: Consulting Psychologists Press, Inc.

Hill, G. D., Atwater, M. M., & Wiggins, J. (1995). Attitudes toward science of urban seventh-grade life science students over time, and the relationship to future plans, family, teacher, curriculum, and school. Urban Education, 30(1), 71-92.

Jensen, R. A., & McMullen, D. (1994, April 4-8, 1994). A study of gender differences in the math and science career interests of gifted fifth and sixth graders. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Jovanovic, J., & Dreves, C. (1998). Students' science attitudes in the performance-based classroom: Did we close the gender gap? Journal of Women and Minorities in Science and Engineering, 4, 235-248.

Kaufman, A. S., & McLean, J. E. (1998). An investigation into the relationship between interests and intelligence. Journal of Clinical Psychology, 54(2), 279-295.

Lapan, R. T., Boggs, K. R., & Morrill, W. H. (1989). Self-efficacy as a mediator of Investigative and Realistic General Occupational Themes on the Strong-Campbell Interest Inventory. Journal of Counseling Psychology, 36(2), 176-182.

Lapan, R. T., McGrath, E., & Kaplan, D. (1990). Factor structure of the Basic Interest Scales by gender across time. Journal of Counseling Psychology, 37(2), 216-222.

Lapan, R. T., Shaughnessy, P., & Boggs, K. (1996). Efficacy expectations and vocational interests as mediators between sex and choice of math/science college majors: A longitudinal study. Journal of Vocational Behavior, 49, 277-291.

Lenox, R. A., & Subich, L. M. (1994). The relationship between self-efficacy beliefs and inventoried vocational interests. The Career Development Quarterly, 42(4), 302-313.

Miller, L., & Budd, J. (1999). The development of occupational sex-role stereotypes, occupational preferences and academic subject preferences in children at ages 8, 12, and 16. Educational Psychology, 19(1), 17-35.

Moffat, N., Piburn, M., Sidlik, L. P., Baker, D. R., & Trammel, R. (1992, March). Girls and science careers: Positive attitudes are not enough. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, MA.

National Science Foundation. (1999). Women, minorities, and persons with disabilities in science and engineering: 1998 (NSF 99-87). Arlington, VA: National Science Foundation.

National Science Foundation (2000). Women, minorities, and persons with disabilities in science and engineering: 2000 (NSF 00-327). Arlington, VA: National Science Foundation.

O'Brien, V., Kopala, M., & Martinez-Pons, M. (1999). Mathematics self-efficacy, ethnic identity, gender, and career interests related to mathematics and science. Journal of Educational Research, 92(4), 231-235.

Pedhazur, E. J. (1997). Multiple regression in behavioral research: Explanation and prediction. (3rd ed.). Forth Worth, TX: Harcourt Brace College Publishers.

Phillips, K. A. (2000). High school females' interests in physical science and related careers one year after participation in a summer intervention program (Doctoral dissertation, University of Missouri-Columbia, 2000). Dissertation Abstracts International, 61, A2243.

Riesz, E. D., McNabb, T. F., & Stephen, S. L. (1997). Gender patterns in science attitudes and achievement: Report of a longitudinal study. Journal of Women and Minorities in Science and Engineering, 3, 161-183.

Schmidt, D. B., Lubinski, D., & Benbow, C. P. (1998). Validity of assessming educational-vocational preference dimensions among intellectually talented 13-year-olds. Journal of Counseling Psychology, 45(4), 436-453.

Simpson, R. D., & Oliver, J. S. (1985). Attitude toward science and achievement motivation profiles of male and female science students in grades six through ten. Science Education, 69(4), 511-526.

Simpson, R. D., & Oliver, J. S. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. Science Education, 74(1), 1-18.

Simpson, R. D., & Troost, K. M. (1982). Influences on commitment to and learning of science among adolescent students. Science Education, 66(5), 763-781.

Talton, E. L., & Simpson, R. D. (1985). Relationships between peer and individual attitudes toward science among adolescent students. Science Education, 69(1), 19-24.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: A meta-analysis of the literature from 1970 to 1991. Journal of Research in Science Teaching, 32(4), 387-398.

White, D. D. (1998). Gender, and the relations among measures of math and science interests, self-estimated abilities, and abilities (Doctoral dissertation, University of Minnesota, 1998). Dissertation Abstracts International, 59, B3729.

Table 1.
Reliability and validity information for selected OSs from the SII (Harmon et al., 1994).

Occupational Scale	Three-to-Six Month Test-Retest Reliability	Tilton Percent Overlap
Chemist	0.95	34
Engineer	0.94	45
Mathematician	0.94	21
Physicist	0.94	19

Note. Adapted from Strong Interest Inventory Applications and Technical Guide (p. 114), by L. W. Harmon et al., 1994, Palo Alto, CA: Consulting Psychologists Press, Inc.

Table 2.
Mean and Standard Deviation Scores for SII Scales

	Pretest		Posttest	
Score	M	SD	M	SD
Investigative Factor	51.14	6.43	51.63	7.24
Chemist OS	35.38	11.92	34.72	12.19
Engineer OS	36.91	11.75	38.16	12.49
Mathematician OS	19.13	12.34	20.66	14.20
Physicist OS	23.16	12.33	23.22	14.59

Note. The Investigative Factor was composed of the mean of the Mechanical Activities, Science, and Mathematics Basic Interest Scales of the SII.

Table 3.
Repeated Measures GLM Analyses of Variance for SII Scores

Source	df	Mean Square	F	p
Investigative Factor				
Time	1	3.835	0.27	0.61
Error	31	14.011		
Chemist OS				
Time	1	6.891	0.13	0.72
Error	31	53.407		
Engineer OS				
Time	1	25.000	0.76	0.39
Error	31	33.000		
Mathematician OS				
Time	1	37.516	0.89	0.35
Error	31	42.129		
Physicist OS				
Time	1	0.063	0.00	0.97
Error	31	47.675		