Physical Science Interests and Strong Interest Inventory Profiles of Females in a Residential Summer Program

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The National Science Foundation (NSF, 1999) has reported that women are approaching parity with men in science and mathematics course taking in high school and in the number of science and engineering bachelor's degrees awarded in the United States. In 1994, the same percentages of females and males were enrolled in advanced mathematics courses in high school. In science courses, females are showing greater participation than males in some areas, as 95 percent of females and 92 percent of males enrolled in biology, and 59 percent of females and 53 percent of males enrolled in chemistry. Females, however, continue to lag in enrollment in high school physics, where 22 percent of females participate, compared to 27 percent of males.

In 1995, women earned 46 percent of bachelor's degrees in science and engineering fields. When this figure is examined by science type, one discovers that women earned only 35 percent of physical and earth science degrees and only 17 percent of engineering degrees (NSF, 1999). While women are fully participating in the biological sciences, with 52 percent of bachelor's degrees in 1995, the significantly lower participation in the physical sciences and engineering persists.

Upon examining the above figures, some may dismiss the differential rates of participation in the physical sciences and engineering by women as unimportant. Others contend that the full proportional participation by females in these fields is desirable and warrants research and intervention efforts. Numerous intervention programs have been conducted over the last 20 years aimed at encouraging precollege women to persist in science. In an overview of these efforts, Matyas (1992) identified students, parents, and teachers as the groups that have been the focus of these intervention efforts. The target variables for these programs include many of the following factors: attitudes and perceptions of science; interest in science/mathematics/engineering courses and careers; motivation; self-confidence; expectations of success; and behaviors related to these areas. Program models include career days, field trips, test-taking-skills training, academic enrichment programs (after-school, Saturday academies, summer workshops, computer camps, university accelerated programs, and academic contests), internships and summer jobs. Most of these intervention programs target female students directly (Atwater, Colson, & Simpson, 1999; Baker, Lindsey, & Blair, 1999; Bartsch, Snow, & Bell, 1998; Conwell & Prichard, 1992; Evans, Whigham, & Wang, 1995; Riesz, McNabb, & Stephen, 1997; Romanello, 1999); however, some programs are designed to affect change through more equitable teaching practices (Behm, 1996; Kahle & Rennie, 1993; Mason & Kahle, 1988) or parental involvement (Shore, 1996).

Due to limitations in funding and personnel and to the long-term nature of some of the factors of interest, most of these intervention efforts have had limited evaluation efforts. Often evaluation is limited to surveys of the participants to find out what they liked and did not like with the aim of improving the program, but without addressing the effectiveness of the program in terms of the factors it was attempting to affect. Evaluation is also most often conducted immediately following the intervention. The evaluation efforts to assess the impact of programs designed to address the underrepresentation problem have been limited. Often, such efforts have

consisted only of informal participant surveys immediately following the program (Conwell & Prichard, 1992; Jordan, Hawkins, Hubbard, & Miles, 1996; Romanello, 1999; Worrell, 1987; Worthy, 1989).

One indicator of a student's intention to pursue a science career is the science classes they complete in high school. From 1982 to 1994, the percentage of females that enrolled in biology rose from 78 percent to 95 percent (NSF, 1999). Thirty percent of females enrolled in chemistry in 1982, while 59 percent did so in 1994. For physics, the increase has also been substantial, rising from 10 percent in 1982 to 22 percent in 1994. In addition to participation in science courses, the students' attitudes toward the subjects of those courses may also play a role in future participation. Numerous researchers have reported that throughout upper elementary, middle school and secondary school males have expressed more positive attitudes toward science than have females (Catsambis, 1995; Colley, Comber, & Hargreaves, 1994; Moffat, Piburn, Sidlik, Baker, & Trammel, 1992; Simpson & Oliver, 1985; Simpson & Oliver, 1990; Weinburgh, 1995). Additionally, when females' interests are studied further, a distinct preference for biological sciences over physical sciences emerges (Baker & Leary, 1995; Farenga & Joyce, 1999; Taber, 1991).

Farenga and Joyce (1999) report that both female and male upper elementary students perceive physical science and technology-related courses to be more appropriate for males to study and life sciences appropriate for females. Even among physics content topics, gender differences emerge. Taber (1991) found that eleven year-old boys were more interested in machinery-related physics topics, such as guns, bombs, missiles, cars, boats, rockets, space travel, robots, and electricity, while girls were more interested in health-related physics topics and rainbows. Hoffmann (1989) also found that females were more interested in natural phenomena and boys in how new technology works. The differences in female and male interests were stable across the five-grade span. Similarly, Jones and Kirk (1990) found gender differences in interest in applications of physics topics. Females were more interested in medical applications and aesthetic examples such as rainbows, while males were interested in new technologies, such as cars and lasers.

Programs designed to increase student participation in science have often focused on science in general or on the biological sciences (Atwater, Colson, & Simpson, 1999; Baker, Lindsey, & Blair, 1999; Bartsch, Snow, & Bell, 1998; Conwell & Prichard, 1992; Evans, Whigham, & Wang, 1995; Riesz, McNabb, & Stephen, 1997). The enrollment and degree data presented earlier indicate that interest and participation in the physical sciences should specifically be targeted for intervention programs.

The purpose of this study was to determine the interest in physical science careers and activities of a group of females who voluntarily enrolled in a summer, hands-on, residential, physical science program, with the long-term goal of determining methods to affect that interest level.

Methods

The 1998 Newton (New Experiences for Women in Science and Technology) Summer Science Academy was a 10-day residential program designed to provide an integrated experience in mathematics, engineering and the physical sciences for young women entering grades 10-12. The academy was piloted in 1997 with a 5-day non-residential experience (Chandrasekhar, Phillips, Litherland, & Barrow, 1999).

Thirty-three young women participated in the 1998 academy. The participants applied for admission after being notified about the program by their science teachers and/or by an

application brochure sent to their homes. Admission was based on school mathematics and science grades and a 300-word essay addressing the applicant's desire to attend the academy. All applicants were accepted for participation. Due to incomplete data for one participant, 32 subjects are included in this study.

Four instruments to assess interest in science were administered to the students at the beginning of the program: the Attitude Toward Science in School Assessment (ATSSA) (Germann, 1988), a modified Science Experiences Survey (SES) (Mason and Kahle, 1988), a modified Course Selection Survey (CSS) (Farenga, 1995) and the Strong Interest Inventory (SII) (Harmon, Hansen, Borgen, & Hammer, 1994).

The ATSSA is a 14-item instrument with a unidimensional view of attitude. The items are scored on a five point Likert scale; 10 items are stated positively and five items are stated negatively. The maximum score is 70 and the minimum is 14. The SES is designed to identify common scientific activities and materials used by students outside of school. The original 40 items was modified by Farenga (1995), and further by Chandrasekhar and her colleagues (Chandrasekhar et. al, 1999), resulting in 31 items. Students indicate how often they participate in various science-related activities by marking one of four choices: frequently, fairly often, seldom, and never. The modified CSS consisted of 12 science courses and 12 non-science courses of which the students were to choose eight that they would like to study in high school. The SII is one of the most widely used inventories for assessing career interest. The 1994 version provides results on the six Holland General Occupational Themes, 25 Basic Interest Scales, 109 Occupational Scales, and four Personal Style Scales.

Findings

ATSSA. As expected, the participants had positive attitudes toward school science, indicated by a mean of 61.5 on the ATSSA. The standard deviation was 7.5.

SES. The results of the Science Experience Survey are presented in Table 1. The four responses were coded 1=never, 2=seldom, 3=fairly often, 4=frequently. Therefore, all of the means fall below "fairly often" except for "I listen to science or medical reports on news programs" and "I have played with objects found in nature."

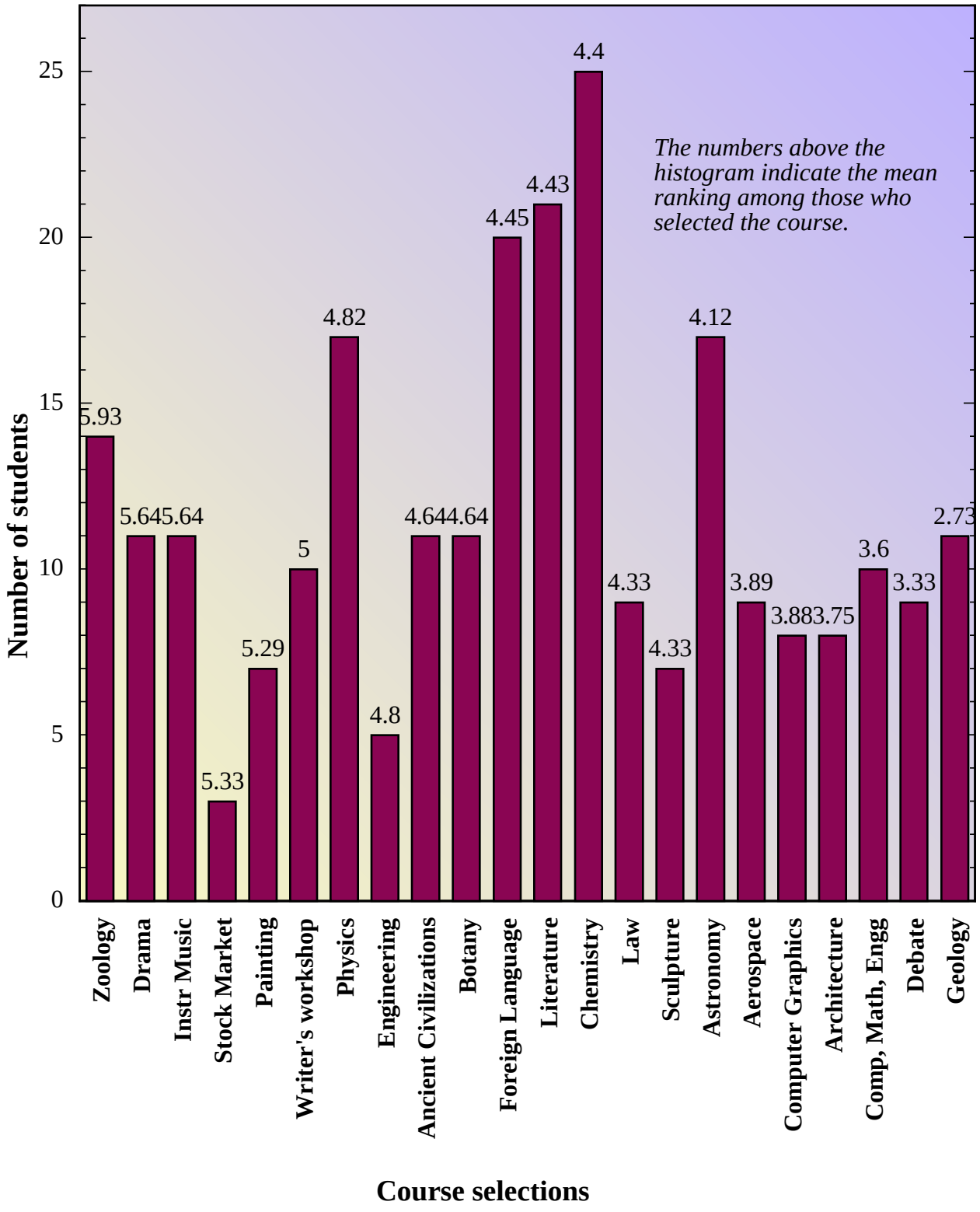
CSS. In the Course Selection Survey, the students were asked to rank the top eight courses that they would like to study in high school from a list of 12 science-related course and 12 non-science related courses. Figure 1 shows the results of this ranking. The number of students selecting each course is noted by the histogram and the mean ranking for each course among the students selecting it is indicated on the top of each column. For example, 25 students indicated they would be interested in taking chemistry, the most of any course. Among those 25 students, the mean ranking for chemistry was 4.4, with 8 being most interested and 1 being least interested.

SII. The two General Occupational Themes (GOT) from the SII that are related to the emphasis areas for the Newton Academy are Realistic (R) and Investigative (I). The R-Theme measures interest in building and repairing objects and the I-theme measures interest in researching, analyzing and inquiring. For the R-Theme, the mean score for the academy participants was 44.4 (SD=9.5), slightly lower than the mean score of 46.7 (SD=9.1) for the female General Reference Sample (a sample of 9,467 women used to provide a norm reference for the SII). For the I-Theme, the academy participants had a mean score of 53.8 (SD=7.4), higher than the mean of 49.0 (SD=10.3) for the female General Reference Sample (see Table 2). Both the R- and I-Theme means reflect an average level of interest in these two areas. Another

method of interpreting the GOT data is to look at the participants' Theme codes. These codes are two or three letter codes indicating the GOTs in which the students scored the highest, Table 1.

Means and standard deviations for the items on the Science Experience Survey.

Item	M	SD
I have read science articles in magazines	2.30	0.77
I have read science articles in newspapers.	2.18	0.73
I have watched science programs on television (for example 3-2-1 Contact, NOVA, Nature, National Geographic, Discover).	2.76	0.87
I have read books about science or scientists.	2.33	0.89
I have talked about science topics with my friends.	2.52	0.67
I have worked on science projects (for example 4-H fair, Brownie or Girl Scout project).	2.30	0.77
I have worked with science-related hobbies.	2.73	0.88
I have listed to science or medical reports on news programs.	3.21	0.70
I have visited a planetarium or aquarium.	2.70	0.73
I have visited a weather station.	1.48	0.71
I have taken a tour of a recycling plant or sewage treatment plant.	1.48	0.71
I have visited a natural history or science center or a nature center.	2.79	0.78
I have visited a cave, mine, or rock quarry.	2.94	0.83
I have visited a fish hatchery or other scientific research center.	2.03	0.81
I have viewed an archaeological site.	1.70	0.88
I have taken care of farm animals.	2.15	1.03
I have visited the mountains.	2.48	0.97
I have visited a national park, nature preserve, or wildlife refuge.	2.64	0.96
I have taken a tour of an animal hospital.	1.94	1.05
I have taken a tour of a hospital, medical, or dental facility.	2.58	0.94
I have taken something apart to see how it works.	2.45	0.87
I have performed a chemical experiment or used a chemistry set.	2.67	0.96
I have looked through a telescope at the night sky.	2.73	0.76
I have found a fossil.	2.52	1.00
I have fixed something mechanical (for example, a bicycle).	2.36	0.99
I have fixed something electrical.	1.91	0.84
I have played with objects found in nature (for example, rocks, water, made a whistle from a blade of grass, made leaf rubbings with crayon and paper)	3.06	0.86
I have viewed a solar or lunar eclipse.	2.76	0.97
I have helped someone work on a car (for example, changing the oil, adding water to the radiator).	2.18	1.01
I have made model rockets, cars, or airplanes.	2.03	0.98
I have used LEGO or similar equipment.	2.97	0.85


Number of students
0
5
10
15
20
25
5.93
5.64
5.64
5.33
5.29
5
4.82
4.8
4.64
4.64
4.45
4.43
4.4
4.33
4.33
4.12
3.89
3.88
3.75
3.6
3.33
2.73
The numbers above the histogram indicate the mean ranking among those who selected the course.
Zoology
Drama
Instr Music
Stock Market
Painting
Writer's workshop
Physics
Engineering
Ancient Civilizations
Botany
Foreign Language
Literature
Chemistry
Law
Sculpture
Astronomy
Aerospace
Computer Graphics
Architecture
Comp, Math, Engg
Debate
Geology
Course selections

regardless of actual numerical score. Twenty-two percent of the participants' (7 students) Theme codes contained both I and R. An additional 53% of the students (17 students) had an I in their code, and 3% (1 student) had an R in her code. Twenty-two percent (7 students) had neither I nor R in their Theme code.

Of the 25 Basic Interest Scales, three are directly relevant to the activities of the Newton Academy: Mechanical Activities, relating to the R-Theme, and Science and Mathematics, relating to the I-Theme. The participants' mean scores for these scales are shown in Table 2. The Mechanical Activities mean is similar to that of the female General Reference Sample, while the means for the Science and Mathematics scales reflect a higher level of interest in these areas for the academy participants than for the general population of women. All of the means for the Basic Interest Scales fall in the range of average interest.

Table 2.

Means and standard deviations for selected GOT and BIS categories from the Strong Interest Inventory. The data for the Female General Reference Sample from Harmon et al., 1994.

	Academy Participants (N=32)		Female General Reference Sample (N=9, 467)	
	Mean	SD	Mean	SD
R-Theme	44.4	9.5	46.7	9.1
I-Theme	53.8	7.4	49.0	10.3
Mechanical Activities	46.3	10.0	46.8	8.9
Science	55.0	7.6	48.8	9.9
Mathematics	51.8	7.3	48.8	10.0

Of the 109 occupations featured on the SII, four were chosen for analysis in this study: Chemist, Engineer, Mathematician, and Physicist. The day-to-day activities of the Newton Academy are designed to expose the students to the professional tasks of these occupations. The means and standard deviations for the occupational scales are shown in Table 3. The scores on the Occupational Scales measure how closely a person's likes and dislikes match those of people satisfactorily employed in that occupation. The values in Table 3 are compared to standard scores (mean=50, SD=10) for women in each of the listed occupations. Scores of 40 or above indicate similar interests as those already in an occupation.

Table 3.

Means, standard deviations, maxima, and minima for the Newton Academy participants on selected Occupational Scales from the SII.

	Mean	SD	Maximum	Minimum
Chemist	35.5	11.8	8	60
Engineer	36.6	12.0	17	63
Mathematician	19.5	11.9	-7	46
Physicist	23.2	12.3	-3	53

As can be seen from Table 3, the participants' scores varied widely on these four Occupational Scales. On the Chemist scale, 10 of the 32 participants scored 40 or above, indicating similar likes and dislikes to employed female chemists. Similarly, 11 participants scored 40 or above on the Engineering scale. However, only one participant scored in the similar range for Mathematician and only two participants did so for Physicist.

The last scale from the SII that was selected for this study is the Personal Style Scale relating to Risk Taking. The mean for the Newton Academy participants on this scale was 52.6 (SD=11.5). These values can be compared with the female General Reference Sample mean of 46.9 and standard deviation of 9.7. For this scale, values higher than the mean indicate a greater willingness to take chances, appreciate original ideas, and enjoy thrilling activities. Fifteen of the participants scored above the 75th percentile in Risk Taking, with 13 scoring above the 90th percentile.

Discussion

The participants of the Newton Academy showed fairly strong interest in taking further physical science courses in high school, with 78 percent indicating an interest in taking chemistry and 53 percent in taking physics. These numbers do not correspond with the gender stereotyping in course selection found by Farenga and Joyce (1999), and the values greatly exceed the national percentages of females enrolling in chemistry and physics in high school (NSF, 1999). These higher values would be expected from a group who voluntarily enrolled in a summer physical science enrichment program. These favorable course taking patterns also correspond with a high mean for the group on the ATSSA, indicating a favorable attitude toward the activities and content of school science courses.

However, the results from the SII provide a different profile of this group. As a whole, the group was not more likely to be interested in the Realistic and Investigative science and engineering-related themes than were females in general in the population. Only six percent (N=2) of the students' profiles indicated similar interests to employed female physicists, 31 percent (N=10) to female chemists and 34 percent (N=11) to female engineers. These dissimilarities may be due to a lack of knowledge and experience with the day-to-day activities of people in these professions. The results of the SES indicated a lack of experience in most science-related activities, particularly those relating to physical science and engineering. It is possible that the students' interest in these areas would be enhanced by participation in a program providing hands-on activities along with other factors such as providing female role models and working in an all-female setting.

The students showed a greater desire for risk-taking than do females in the general population, a result that is not surprising given the students' age. Harmon, et al. (1994) indicate that the Risk Taking score decreases with age, as subjects realize the consequences of risk taking behavior. One manifestation of this willingness to take risks may well be the voluntary participation in a physical science program with which the students have had little previous experience. It is encouraging that voluntary programs such as the Newton Academy have the potential to influence students and that such programs are not only serving students who have solidified their interests in science and engineering fields.

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