4-H Participation and Science Interest in Youth

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Abstract: The study reported here investigated the impacts of participation in 4-H on young people's interest and participation in science. Survey data were collected from relatively large and ethnically diverse samples of elementary and high school-aged students in California. Results indicated that although elementary-grade 4-H members are not more interested in science than other youth, by high school, participation in 4-H is associated with a greater number of science classes and higher-level science coursework. These results suggest that the 4-H program may have the ability to influence science interest and participation in the long term among its members.

Background

Science achievement in the United States among K-12 youth has lagged behind many of their grade-level peers from other countries for many years, prompting much concern from researchers (e.g., Miller, 2006; Murcia, 2007; Scearce, 2007) as well as from federal agencies such as the National Academy of Sciences (2007). The 2007 Trends in International Mathematics and Science Study (TIMSS) showed that that although participating U.S. fourth-grade students' science achievement scores were higher than were those of 25 of the 35 other participating countries, the scores among this age group has been declining over time. Average science achievement among U.S. fourth-graders was lower in 2007 than it was in 1995 (Kerachsky, 2008), and the percentage of U.S. fourth-graders who performed at advanced levels in science also declined during this time (Kerachsky, 2008).

Furthermore, results from the 2005 National Assessment of Educational Progress (NAEP) revealed poor science achievement at all three grade levels tested—fourth, eighth, and twelfth—with the lowest scores among high school students (McGrath, 2008). More specifically, the NAEP data showed that the majority of students tested scored at either the basic (31%) or below basic (40%) levels, and the proportion of students at the below basic level increased dramatically from fourth grade to eighth grade and again from eighth grade to twelfth grade (McGrath, 2008).

Deficits in science literacy among school-age youth in the U.S. raise serious societal concerns. Science is integral to our daily lives, to our nation's economy, and to global economies, and "…we cannot afford [a scientifically] illiterate society" (Nelson, 1999, p. 14). Moreover, K-12 students who score below the proficient level and, in particular, those who score below the basic level on NAEP assessments will lack the foundational knowledge and skills necessary for scientific careers and full participation in today's knowledge society (National Academy of Sciences, 2007). Latino and African American youth are at particular risk for low scores on science assessments. Although some gains in achievement among Latino and African American youth with respect to their white peers have been shown, gaps persist in several areas, including advanced science course selection among high school-aged youth (Metz, 2010).

As one of the first steps young people take toward a science career, high school science courses help to prepare young people for college majors and, later, careers in science. In addition, a broad science background is useful for participation in 21st century society (National Academy of Sciences, 2007). Unfortunately, the low level of science achievement among U.S. high school students appears to be affecting youth in higher education. The number of college students in the U.S. who earn undergraduate degrees in science is declining and falls well below most other developed nations, thus compromising the nation's ability to train new scientists and remain scientifically competitive on a global scale (National Academy of Sciences, 2007).

In response to these concerns, President Obama announced a campaign to encourage companies to support efforts to increase student participation in science, technology, and mathematics (Chang, 2009). The idea behind this program is that if children develop interests in these areas, they may be more likely to want to study them at higher levels and to pursue careers in these fields. The focus of

the Obama administration to increase interest and study in the areas of science, mathematics, and technology will be on out-of-school opportunities for middle school age youth. The goal of this campaign is to let children know that studying science is fun and important, and that the advancement of science will contribute to their communities and society.

Educational research has sought to learn more about what stimulates students' interests in science and those factors that can impede or encourage further study in these subjects, such as teaching methods that increase student excitement and curiosity. Despite some promising evaluation research on nonformal science education, such as the impacts of educational delivery in an experiential-learning, inquiry format, less attention has been paid to the impact that out-of-school programs may have on science interest in youth. Research on science programs in nonformal settings has suggested that nonformal science programs have the potential to increase science interest among young people and that these programs can have long-lasting impacts. Some examples of these evaluations include:

- In an investigation of the long-term impacts of a summer science program on high school students' interest in science, Markowitz (2004) found that 82% of the students reported a greater improvement in their performance in science, approximately 80% reported a greater interest in exploring a science-related career, and 49% indicated that their participation led them to take part in additional science programs. Furthermore, a follow-up survey administered to students up to 7 years after participating in the program found that many students who had indicated at the completion of the program that the program contributed to their interest in science eventually majored in science.

- Gibson & Chase (2002) studied the effects of a 2-week inquiry-based science camp on middle-school students' interest in science and science-related careers. The camp provided hands-on laboratory and field experiences. Results indicated that students who participated in the camp reported significantly more interest in science at high school than students who did not participate in the camp. In addition, interviews conducted with participants 5 years following their participation in the program indicated that students wanted opportunities to do hands-on science activities, and they emphasized the importance of their science teachers in nurturing their interest and curiosity in science.

- In an inquiry involving high school-aged youth, Stake and Mares (2001) evaluated the influence of science enrichment programs on students' confidence, motivation, and attitudes toward science and career aspirations. Students who participated in science enrichment programs of longer duration (two programs totaling 10 weeks of participation) reported more positive changes than those who participated in a shorter program (two programs of 4-6 weeks' duration). Family support and encouragement for participation, as well as science teachers who were encouraging and supportive, were strong predictors of program impact.

For the project reported here, researchers investigated the impacts of participation in the California 4-H Youth Development Program on young people's interest and participation in science. Specifically, the study examined whether involvement in 4-H was associated with science interest among youth in 4th to 6th grades and whether participation in 4-H was related to the amount and level of science coursework taken by high school students.

Methods

The study used data from two separate surveys, one for elementary school students and one for high school students. The elementary school survey instrument was designed to ascertain interest in science, engineering, and technology, and consisted of eight questions on science interest drawn, and in some cases modified, from a variety of previously published science interest surveys for young people (Donaldson, Chen, Toye, Clark, & Sheppard, 2008; Hulett, Williams, Twitty, & Turner, 2004; Fraser, 1981; Silverstein, 2002; Stokking, van Aert, Meijberg, & Kaskens, 1999). The survey also included basic demographic questions, as well as 4-H membership and project involvement questions. The survey for high school youth consisted of five questions: grade; gender; race/ethnicity; current or former 4-H membership and project involvement; and a checklist for science classes taken in high school. (This list varied depending on what courses each school offered.)

Youth in the study were drawn from schools and after school programs in eight California counties. A convenience sample of schools was used, but within schools all eligible students were surveyed (4th to 6th graders or 10th-12th graders depending on the school). The elementary school survey participants consisted of 803 students in grades 4-6 from four elementary schools and six after-school programs. The high school sample included 1,099 sophomores, juniors, and seniors from three schools. Respondents to the high school survey were predominantly juniors (45%) and seniors (52%), with only 2.6% being sophomores; the intent was to include youth who were old enough to have completed much of their science coursework. Data were entered in Excel and analyzed using SAS (Freund & Littell, 2000), including regression model computation using Proc Reg.

Results

Demographics for all participants are shown in Table 1. Slightly more than one-half of the youth in each sample were male. The elementary school sample was somewhat less likely to be white (53.6%) than the high school sample (65.9%). The elementary school sample was more likely to include current or former 4-H members (24%) than the high school sample (9.3%). The elementary school surveys were completed by youth residing in a different geographic area than youth who completed the high school surveys, which may account for the differences in these demographic measures.

Table 1.
Demographics of the Study Sample

	4th to 6th Grade Sample		High School Sample	
Race/ethnicity*	Number	Percentage	Number	Percentage
Asian or Pacific Islander	30	4.0	54	4.9
Latino	360	47.7	383	34.5

Native American	57	7.5	57	5.1
White	405	53.6	731	65.9
African American	24	3.2	57	5.1
Boys	408	51.8	556	50.3
Girls	380	48.2	550	49.7
4-H member, current	134	17.0	37	3.4
4-H member, past	55	7.0	65	5.9
Never was in 4-H	599	76.0	997	90.7
*Race/ethnicity numbers total more than the sample because youth were allowed to check more than one race/ethnicity. Therefore, the percentages are out of all who responded to the race question (755 elementary students and 1109 high school students) rather than out of the total of the race categories.				

Youth in the elementary school sample were asked several questions about their interest in science. Results are shown in Table 2. There were no statistically significant differences between the current, former, and non-4-H youth in the sample for any of the questions. Three questions approached significance with $p<.10$; for two of these items (Questions 3 and 5), current 4-H youth were slightly more likely than the other youth to give a pro-science response, while for Question 6, the more science-positive response was given by the youth who had never been in 4-H. Overall, the results on science interest in elementary school showed that current 4-H youth, former 4-H youth, and non-4-H youth reported similar levels of interest in science and science-related careers.

Table 2.
Science Interest Survey Question Results for Elementary School Sample

Question	Current 4-H	Former 4-H	Non-4-H	p-value
	Percent who "Agree" or "Strongly Agree"			
1. I look forward to science lessons in school.	77.4	76.4	72.7	.2362
2. A job as a scientist would be boring.	35.3	29.1	37.1	.5312

3. Science is useful in everyday life.	85.6	76.4	77.7	.0618
4. I like reading books about science, nature, or space.	48.1	65.5	57.5	.1054
5. Science at school is hard.	21.1	27.8	29.1	.0685
6. I would enjoy visiting a science museum on the weekend.	64.9	65.5	71.7	.0914
7. I like to figure out how things work.	84.3	85.2	83.9	.8708
	Percent yes			
8. Would you be interested in attending a science camp?	50.8	79.6	59.0	.3100

The sample of high school students was asked what science courses they had taken (Table 3). Although the average grade level was about the same among all three groups (current 4-H, former 4-H, and non-4-H), those individuals who were current 4-H members had taken significantly more science courses than had youth in the other two groups. On average, current 4-H youth had taken nearly four science courses, former 4-H youth had taken about 3.3, and youth who had never been in 4-H had taken approximately 2.9 (p<.0001). There were also significant differences between the three groups on the level of the science coursework taken, with 4-H youth taking more advanced scientific coursework. Current 4-H members were significantly more likely than former 4-H youth or youth who had never participated in 4-H to have taken Advanced Placement (AP) courses, marine biology, agriculture, physics or physical science, and natural resource management. Conversely, 4-H members were less likely than other young people to have taken earth science or life science.

Table 3.
Science Courses Taken in High School

Course	Current 4-H	Former 4-H	Non-4-H	p-value
	n=37	n=65	n=997	
Mean grade level	11.43	11.65	11.49	.0607
Mean number of science courses taken	3.97	3.26	2.89	<.0001
	Percent who have taken…			
Agriculture I	56.3	40.6	20.6	.0001

Agriculture II	37.5	28.1	7.9	<.0001
ROP Natural resource management	37.5	31.3	14.5	.0023
Earth science	62.2	66.2	74.8	.0269
Life science	18.8	31.3	47.7	.0067
Biology	81.1	80.0	87.8	.0515
Biology 1	28.6	21.2	11.6	.0049
Biology 2	19.1	3.0	2.1	<.0001
Marine Biology	19.1	18.2	8.6	.0200
AP Biology	13.5	0.0	1.8	.0004
Chemistry	48.7	52.3	53.9	.5120
AP Chemistry	13.5	0.0	0.4	<.0001
Physics	18.9	12.3	6.2	.0006
Physical Science	47.6	24.2	18.6	.0014
AP Physics	9.5	0.0	1.3	.0196
Health	31.3	28.1	30.1	.9755
Anatomy and Physiology	14.3	6.1	8.1	.5121

The relationship between project type and science coursework was also examined. 4-H participants were asked the types of 4-H projects in which they had been enrolled. Table 4 shows the mean number of science courses taken according to the types of projects the high school youth reported. Youth who reported participating in environmental science or natural resources projects, or science, engineering, or technology (SET) projects, had taken the highest number of science courses in high school (mean of 4.9 for both groups). Fewer science courses were taken by youth who participated in animal science, citizenship, or leadership projects.

Table 4.
Mean Number of Science Courses Taken by 4-H Project Type Among Current
and Former 4-H Members

Youth Has Taken:	Number of Youth	Mean Number of Science Courses Taken
Animal project	71	3.8
Citizenship or community service	38	3.8
Leadership and personal development	29	3.9
Arts or communication	26	4.1
Healthy lifestyles	13	4.3
Environmental science or natural resources	10	4.9
Science, engineering and technology	12	4.9
Other types of projects	12	3.8

Linear regression models were computed to estimate the predictors of the number of science courses young people had taken. Before adjustment, current and former 4-H membership were both significant predictors of the number of science courses youth took in high school (p<.0001 for current members and p=.0071 for former members). Models including 4-H membership and demographic data are shown in Table 5. Gender was not a significant predictor of the number of science courses young people took, while there were significant differences among race/ethnic groups, with Asian/Pacific Islander students taking significantly more science courses than other youth, and Latino youth taking fewer. However, even after adjusting for grade level, race/ethnicity, and gender, 4-H membership remained a strong and significant predictor of the number of science courses youth had taken. Current 4-H youth had taken the most science courses, former 4-H members were in the middle, and youth who had never participated in 4-H took the fewest.

Table 5.
Linear Regression Model Predicting Number of Science Courses Taken in High
School

	Parameter Estimate	p-value

Current 4-H member	.970	<.0001
Former 4-H member	.319	.0183
Never 4-H	(ref)	
10th grade	-.111	.5923
11th grade	-.347	<.0001
12th grade	(ref)	
Male	(ref)	
Female	-.042	.5122
White	(ref)	
Latino	-.112	.0476
African American	.192	.2016
Asian/Pacific Islander	.383	.0125
Native American	.092	.5546

Discussion

The results of the survey suggest that youth who participate in 4-H do not start out with an interest in science or an attitude toward science that is significantly more positive than other young people. However, results show that by high school 4-H participants are taking more and higher-level science courses than other youth, even after adjustment for demographic differences among the groups. Furthermore, youth who participated in science-related 4-H programming, whether environmental science, natural resources, or SET programming, had taken more science courses in high school than either non-4-H youth or youth who had taken part in other types of 4-H programs. While this is a cross-sectional study and thus it is not possible to demonstrate a causal link between 4-H participation and science courses, the data are suggestive that 4-H may have a longitudinal impact on science interest and participation. Exposure to 4-H science-related programming in particular appears to be significantly associated with higher-level science coursework taken in high school.

Addressing Youth Science Literacy Through Nonformal Education Programs

Improving science literacy among K-12 youth in the United States will require a variety of strategies.

Addressing deficits in school-based science education is an important component of this goal (Smith & Trexler, 2006). However, the results from the study reported here provide further support for the idea that nonformal science programming also can play an important role in developing science engagement. Youth who take more and higher-level science courses in high school will be more likely to be on a path to attend college, to major in science in college, and to have a science career. In a parallel finding, Stake & Mares (2001) found that students with a history of science-related experiences gained more from science programs.

A wide variety of opportunities, including nonformal education programs, exist for youth to learn science outside of the school setting (Rahm, 1999). Nonformal education programs occur during out-of-school hours, offer organized learning experiences outside of the formal classroom (Walker & Dunham, 2002), and typically occur under the guidance of an adult staff member or volunteer educator (Carlson & Maxa, 1997). A supplement rather than an alternative to school, nonformal education programs (e.g., 4-H, Boy Scouts, Girl Scouts, Boys and Girls Clubs, camps, and docent-led museum education programs) can provide learning opportunities that expand curriculum offerings and complement classroom teaching (Carlson & Maxa, 1997; Mørch & du Bois-Reymond, 2006). Nonformal learning environments help generate interest and excitement around science that encourage exploration and interactions among learners (Fenichel & Schweingruber, 2010). This higher level of interest in science could be responsible for the results seen here. The science-related 4-H programming taken by youth in the high school sample in the study may have helped to generate a higher level of interest in science among these youth, perhaps resulting in their decision to take more and higher-level science coursework.

Some researchers have promoted nonformal education programs as important resources to help contend with the youth science literacy problem facing the United States today. For example, Kisiel (2006) maintains that if science literacy "is an important goal within our society, then we must consider other learning settings, in addition to school, that can contribute to this goal" (p. 396). Kress, McClanahan, and Zaniewski (2008) state that nonformal programs represent a critical component to the youth science literacy equation and that learning that happens during out-of-school time is as important as learning that occurs in school. Carlson and Maxa (1997) concur with the importance of nonformal science education in addressing youth science literacy and identify the constructivist, interdisciplinary strategies used to teach science in such programs as important to developing an understanding of science.

Although the 4-H Program in the 21st century continues to have a strong agricultural science component, it also offers a wide variety of inquiry-based science, engineering, and technology projects and programs, ranging from animal science to rocketry and earth science, and from plant science to robotics and environmental education (United States Department of Agriculture, 2003). Additionally, the pedagogical strategies emphasized in 4-H include hands-on inquiry and experiential learning (Bourdeau, 2004; Enfield, Schmitt-McQuitty, & Smith 2007; Horton & Hutchison, 1997), approaches that have been shown to be effective in advancing youth science literacy (Beerer & Bodzin, 2004; Marek & Cavallo, 1997; Meichtry, 2005; National Research Council, 1996).

Strengths and Limitations

A strength of the study reported here was the relatively large and ethnically diverse sample that was

included. The study is limited in its ability to draw causal links between 4-H programming and science interest or coursework among youth. The cross-sectional study design cannot eliminate the potential selection effects that could be at play. Youth who are interested in science may be more likely to participate in 4-H and particularly in science-related programming and also to select high level science coursework in high school. Socioeconomic status, which was not measured in the study, could also be a confounding factor affecting 4-H membership and high school science coursework. However, the ability to adjust for both gender and ethnicity, as well as the snapshot of science interest among elementary school students, provide support for the idea that 4-H programming may have played a longitudinal role in high school course selection.

An additional limitation of the study is the somewhat different populations surveyed in the 4th to 6th grade sample compared with the high school sample. It is possible that youths' residence in a different set of counties could affect 4-H project participation and thus their ability to take part in science-related programming. To examine this question further, the percentage of youth in 4-H by project type was analyzed for the most recent 4-H enrollment year (data not shown). Results showed that youth in every county sampled had the opportunity to participate in science programming. There was no statistically significant difference in the percentage of 4th to 6th grade youth who were enrolled in science, engineering, and technology programming in the counties in which 4th to 6th graders were sampled compared with the counties in which high school students were sampled. Among high school students, youth in the 4th to 6th grade sample counties were slightly less likely to take science projects than youth in the high school counties, but this difference was not large (7% vs. 11%).

Conclusions

The results from the study indicate that 4-H participation is associated with a greater number of science classes and higher-level classes in high school, even though 4-H youth do not start out with a higher level of interest in science than do other young people. These results suggest that the 4-H program has the ability to influence science interest and participation in the long term among its members. These results are encouraging given the National Mission Mandate within 4-H to play a significant role in the development of science interest among youth. In 2007, as its official response to the low levels of science, engineering, and technology literacy and workforce preparedness among youth in the United States, National 4-H launched the Science, Engineering, and Technology (4-H SET, now 4-H Science) Initiative (Garrett & Locklear, 2007). Results from this cross-sectional survey suggest that youth who participate in 4-H science-related programming may be more likely to take positive steps in high school toward a future that includes science literacy and in some cases, a science career.

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