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Bringing Up Girls in Science (BUGS): The Effectiveness of an Afterschool Environmental Science Program for Increasing Female Students' Interest in Science Careers

Tandra Tyler-Wood · Amber Ellison · Okyoung Lim · Sita Periathiruvadi

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Abstract Bringing Up Girls in Science (BUGS) was an afterschool program for 4th and 5th grade girls that provided authentic learning experiences in environmental science as well as valuable female mentoring opportunities in an effort to increase participants' academic achievement in science. BUGS participants demonstrated significantly greater amounts of gain in science knowledge as measured by the Iowa Test of Basic Skills in Science (ITBS-S). The original BUGS participants and contrasts have now completed high school and entered college, allowing researchers to assess the long-term impact of the BUGS program. Fourteen former BUGS participants completed two instruments to assess their perceptions of science and science, technology, engineering, and mathematics (STEM) careers. Their results were compared to four contrast groups composed entirely of females: 12 former BUGS contrasts, 10 college science majors, 10 non-science majors, and 9 current STEM professionals. Results indicate that BUGS participants have higher perceptions of science careers than BUGS contrasts. There were no significant differences between BUGS participants, Science Majors, and STEM professionals in their perceptions of science and STEM careers, whereas the BUGS contrast group was significantly lower than BUGS participants, Science Majors, and STEM Professionals. Additional results and implications are discussed within.

Keywords Gender equity · STEM Interest · Female student perceptions of science

T. Tyler-Wood (✉) · A. Ellison · O. Lim · S. Periathiruvadi
Department of Educational Psychology, University of North Texas, P.O. Box 311335, Denton, TX 76203-1335, USA
e-mail: Tandra.wood@unt.edu

Introduction

President Obama's new STEM initiative, "Educate to Innovate" (The White House Office of the Press Secretary 2009) emphasizes the importance of Science, Technology, Engineering, and Mathematics (STEM) education and its improvement. Aligned with this new initiative, it has become even more important to determine the success of programs to improve student knowledge and participation in STEM.

Bringing Up Girls in Science (BUGS) is a demonstration project funded by the gender equity division of the National Science Foundation (NSF) that spanned 2001–2005. This study involved 32 girls in grades 4 and 5 from a mid-sized urban community in North Texas. The program consisted of participation in an after-school environmental science program which utilized a high interest science curriculum with mentor support. It has been 8 years since the completion of the BUGS project, and its year one participants and controls are now out of high school and in college or the workforce. This article examines the short-term effects of the BUGS program on female students' science knowledge, as well as the program's long-term effectiveness on female students' perceptions of STEM careers.

The Gender Gap in Science

It is commonly believed that boys have higher academic achievement in STEM than girls, but some literature suggests that the gender gap is less of an ability gap than a gap in perceptions of science careers. Indeed, girls achieve as well as or even better than boys on many indicators of educational achievement in elementary, secondary school, and college (Freeman 2004). Although there are still some gender differences in science and math, many gender gaps appear to be closing (Freeman 2004). Freeman found that scores fluctuated year by year, but the average scores of boys in calculus, computer science, and science on Advanced Placement (AP) examinations were higher than those of girls. However, there was very little difference between boys' and girls' scores on the math National Assessment of Educational Progress (NAEP) assessment (Freeman 2004). Furthermore, girls continue to perform better than boys in writing and reading and are less likely than boys to have repeated a grade or dropped out of school (Freeman 2004).

While the existence of a gender gap and the actual size of the gender gap in science academic achievement are questionable when various datasets and test scores are compared, the fact that women are underrepresented in STEM careers is considered indisputable (Blickenstaff 2005). Van Langen et al. (2006) studied the influence of the gender achievement gaps worldwide in secondary education on the STEM participation of women. Even though there are considerable differences among countries, the result indicates that the smaller the gender achievement gap for mathematics and science literacy between males and females in secondary education, the greater the STEM participation of females in higher education (Cereijo et al. 2002). Thus, the current study explores whether the BUGS program was effective in improving academic achievement as well as longer term placement in STEM college majors and careers. This study focuses on science rather than STEM as a whole, but both STEM and science literature drive the theory behind this research.

Weinburgh (1995) conducted a meta-analysis of the literature on gender differences in students' attitudes toward science. The correlation between students' attitudes towards science and student achievement was explored. Weinburgh concluded that boys display more positive attitudes towards science and that attitude toward science is highly correlated to science achievement. Baram-Tsabari et al. (2006) noted that the attitude of girls towards science became increasingly negative with age. These researchers also found that girls' interests in science were significantly different from that of boys, as girls preferred biological topics over other science areas. Using these topics of interest as the context for learning science can be valuable to increase girls' interest in science. Girls are much more drawn to science themes that are perceived to have a high social relevance, while boys tend to be more attracted to science themes that are perceived to have a high mechanical or practical relevance (Reid 2003).

Improving the elementary female's perception of science would seem to be an essential goal if one is to increase science achievement in female students and subsequently increase the number of females participating in science careers. There is a lack of long term studies which look at the effectiveness of programs on improving young girls' achievement and attitudes towards science. The BUGS project hopes to establish that girls with improved achievement and attitudes towards science are actually more likely to have positive perceptions of science at the college level.

Narrowing the Gender Gap

Research about ways to narrow the gender gap is abundant. This section of the literature will reflect four specific areas: the characteristics of effective classroom curriculum, the importance of early intervention, targeting girls' perceptions of science careers, and the effects of long-term mentoring.

Characteristics of Effective Classroom Curriculum

Effective science program curriculum for young female students should address the very specific needs of bright and capable female students. The National Science Teachers Association (NSTA) (2003) documents the need to match curriculum and instructional strategies to learning styles. Programs for females should not duplicate programs for male students, but should be equitable, emphasizing hands-on, real-life laboratory experiences while incorporating verbal/language arts components where many females excel (Subrahmanyan and Bozonie 1996). Previous research has indicated that cooperative learning and mentoring programs are effective methods for incorporating a verbal/language arts component into science (Subrahmanyan and Bozonie 1996).

Burkham (1997) emphasized the importance of active classroom involvement as a way of promoting gender equity. Methods to increase active involvement include: engage in real life scientific experiments that personify females' interest areas, increase hands-on experience through lab time, allow girls to share research findings through innovative methods that have a strong verbal component (ex. two way audio visual interactions through the use of the computer), and increase opportunities for cooperative learning (Tyler-Wood 1993). Furthermore, the Institute of Education Sciences (Halpern et al. 2007) recommends the following to encourage and improve the participation of girls in science classes:

- Teach students that academic abilities are expandable and improvable.
- Provide prescriptive, informational feedback.

- Expose girls to female role models who have succeeded in math and science.
- Create a classroom environment that sparks initial curiosity and fosters long-term interest in math and science.
- Provide spatial skills training.

Importance of Early Intervention

Perhaps the most important characteristic of effective science curriculum is early timing of interventions. Interventions should occur prior to high school in order to be effective (Subrahmanyan and Bozonie 1996). Caleon and Subramaniam (2008) studied the attitude of academically talented girls and boys towards science. These researchers discovered that although the gender gap is less evident in the primary years, as students progress through school, the gap becomes greater. To increase the number of women in STEM careers, it is important to prevent the widening of the gap between girls' and boys' attitudes towards science. The researchers also noted that more girls than boys are undecided about their attitudes towards science-related careers during their upper-primary years. In order to assist these undecided students with developing more positive attitudes towards science, Caleon and Subramaniam believe that students should be provided with an opportunity to explore STEM career choices in their primary years.

Ford et al. (2006) noted that in spite of doing well in early grades, girls tend to lose interest in science in the later grades. To engage girls in science, their learning styles and interests should be considered during early science instruction, even if the gender gap is not apparent.

Stoking (1993) studied the attitude of academically talented girls and boys in grade seven participating in the Duke University Talent Identification Program. Student participants rated school subjects and college majors in terms of how much they liked or disliked each subject. Student participants indicated subject preferences according to a forced choice system. Girls consistently rated language arts courses as their favorite courses while boys rated mathematics and science as their favorite courses. Freeman's more current data continues to support these noted differences in preferred course work related to gender (2004). It appears that academically talented girls have already determined specific subject preferences for language arts by the seventh grade. Any plan seeking to increase academically talented girls' perceptions of science should most likely focus on demonstrating the positive aspects of science in the early grades, prior to grade seven. It would also seem important to use teaching strategies in science which have a strong language arts/verbal component to meet the learning style preferences of female students. Oakes (1990) further reiterated the importance of early intervention for increasing girls' choices for a science career with research that indicates that the number of students considering careers in the field of science increases very little after ninth grade. To facilitate gender equity in science, it is critical to identify programs that match girls' learning styles and provide learner-centered materials at an early age.

Targeting Girls' Perceptions of Science Careers

Hamrick and Carlisle (1990) indicated that many women harbor stereotypical ideas about science and scientists. Most women believe science is a male dominated field with few opportunities for female participation. Even when there was no significant difference in the achievement scores of boys and girls in math, girls rated their math abilities lower as early as the elementary grades. Students with more confidence in these subject areas are more likely to perform well and pursue careers in math or science. Girls form perceptions when they observe stereotypes in society in the areas of science and math (Herbert and Stipek 2005).

To attract girls into science, Packard and Nguyen (2003) suggested expanding the range of girls' career-related vision of "possible selves." Girls should be given the opportunity to experience different careers in the sciences and "envision" what their future life might be like if they selected such a career. Career related "visions" can be provided through mentoring and job shadowing. Packard and Nguyen (2003) indicated that career exploration should be a part of the science curriculum in the K–12. Baker and Leary (1995) found that girls expressed more interest in life sciences than physical sciences because they would have more opportunity to help others in life sciences careers. Therefore, the positive impact of different STEM careers on society should be illustrated to them. Early exposure to career possibilities will not only keep girls from rejecting STEM careers either due to lack of information or stereotypical views, but also help girls to explore possible career options. A thorough discussion about different careers and the financial stability that can accompany specific career choices can benefit all students, especially students from low-income backgrounds. The problem of attracting females into science careers has been documented for many years (Baker and Leary 1995). Providing girls with the opportunity to see the advantages of selecting a science career at an early age should increase the opportunity for girls to select a STEM career.

Long-Term Mentoring

Exposure to women in scientific careers over longer periods of time as teachers, mentors, or though internships results in positive attitude changes (Tsuji and Ziegler 1990). A long-term intervention supported by appropriate mentoring would seem to provide important elements to sustain a long-term commitment to the study of science for highly capable elementary aged girls (Coleman 1998). Lanz, in Chipman, Brush and Wilson (1985) indicated that long-term programs are more effective in changing academic attitudes. One-day or short term programs often do not involve consistent, active participation and rarely address the reasons females do not take advanced science courses. Career opportunities for women have changed dramatically since Lanz' work in the 80's. Therefore, it is important to determine if a year-long program, such as BUGS, provided in more recent years, can result in an increase in female's participation in science coursework at the college level.

Coleman (1998) studied barriers to career mobility and advancement by African-American and Caucasian women. One of the most frequently identified barriers for advancement was lack of opportunity for professional networking and exclusion from the—"good ole boys" network. Coleman indicates that the—glass ceiling "is a very real phenomenon for both Caucasian and African-American females." It is important to provide females an opportunity to network and form support groups. A program for elementary-aged girls that emphasized mentoring and the establishment of a long-term relationship could help young girls establish a pattern of forming career enhancing long term relationships.

Dee (2007) reported positive educational outcomes through same gender interaction effects between a student and teacher. The presence of female mentors or teachers in the STEM areas can not only bolster the confidence of girls in STEM areas, but also help girls understand different problem solving and coping strategies through discussions with role models. When students are provided with mentors, they get a chance to explore different career possibilities in science and math.

According to Packard and Nguyen (2003), mentoring can be a blend of academic, professional or personal function. Mentoring can help to develop career-related identity by modeling career-related possible "selves" to which young girls aspire. Esprivalo-Harrell et al. (2004) drew from the literature to create the following model for the BUGS mentoring relationship: "The mentor creates a social context that fosters interest, participation, and self-concept related to science by encouraging the mentee to think reflectively, question effectively, and develop personal responsibility for her own learning." Positive mentoring relationships may influence a mentee's current self-concept as well as their future self-concept.

Research Questions

1. Initial Study: Will authentic educational experiences in 4th and 5th grade, such as those provided by the BUGS program, increase academic achievement in basic science knowledge?
2. Follow-up Study: Will early science intervention have a long-term positive effect on girls' STEM perceptions and on their future career interest?

Methods

Participants and Activities

The BUGS Program in Detail (2001–2002)

Bringing Up Girls in Science (BUGS) was a 3 year project funded by the National Science Foundation. The study served between thirty and forty female students in grades four and five each year of the 3 year project. The current research reviews data obtained from year one participants. The year one data was selected for analysis because girls in this group are currently entering college, selecting a college major and career path. A group of thirty-two 4th and 5th grade girls was selected to participate in an after-school science program, Bringing Up Girls in Science (BUGS). Participants were selected from a large school district in north Texas. A matched comparison group of thirty-four 4th and 5th grade girls with similar characteristics was selected from another large school district in north Texas. Students in the comparison group were matched on science scores on the third grade administration of the Iowa Test of Basic Skills (ITBS). Each BUGS participant was matched with a girl who scored within three percentile points on the science section of the ITBS (Tyler-Wood and Mortensen 2006).

During year one, 32 of the 35 BUGS participants completed the pre- and post-test administration of the ITBS. The science portion of the ITBS was used to measure participants' achievement gain. Three students missed either the pre- or post-test due to illness, and their scores were not included in the study. The original BUGS program involved participation in an after school outdoor science lab at a local elementary school. Students from three neighboring schools were bused to the school for project participation. The elementary school where the program was held housed a large outdoor environmental lab as well as indoor laboratory facilities. One day each month additional activities were held at the Elm Fork Education Center, the public education branch of the University of North Texas' Environmental Science Program.

Female high school students who were enrolled in the Texas Academy for Mathematics and Science (TAMS) served as mentors for BUGS participants. TAMS provides an opportunity for talented students in mathematics and science to complete the first 2 years of college while earning a high school diploma. Each TAMS student was matched with a BUGS participant on interests in specific science subject areas and interests in extracurricular activities. TAMS students also served as instructional aides for the weekly science lab in which the girls participated. TAMS participants had face-to-face contact with their mentees for approximately 120 min each week throughout the academic year. In addition, mentors contacted mentees through the phone, internet and a website established through the project. TAMS students helped the BUGS participants with science activities each week. In addition, at the end of the year, TAMS participants facilitated the BUGS participants in developing a science project and a hands-on demonstration of a concept in the lab that was presented to parents and faculty at UNT. An adult mentor from the University of North Texas served as a mentor for both the TAMS students and BUGS participants. The role of the adult mentor included providing information on career and educational opportunities in science. The adult mentor met with both the TAMS and BUGS participant two times for a total of 2 h of contact for the academic year. A 2-week summer experience at the Environmental Education Center of Elm Fork was provided for the academic year participants and their BUGS mentors.

For the academic year and summer program, the Science, Technology, and Children Curriculum (STC) curriculum was used. This curriculum provides lesson plans and activities as well as a complete set of materials so that elementary students can participate in "hands-on" science experiments. The goals of the STC Curriculum include:

- Make science relevant, interesting, and challenging for all children.
- Contribute to children's conceptual understanding of their world.
- Help children develop scientific-reasoning and problem-solving skills.
- Foster the development of scientific attitudes, such as curiosity, respect for evidence, flexibility, and sensitivity to living things.

Five units were available for use during the academic year program. These units included: animal studies, land and water, micro-worlds, experiments with plants and floating and sinking. A unit on micro-worlds was used for the summer program. Each STC unit was based on a learning cycle that included four stages: focus, explore, reflect, and apply. In the first stage, the prior knowledge and experience of the learner was addressed. The students then focus on what they would like to know about a particular topic. Next, the students explore a scientific concept or phenomenon as they engage in a particular activity. Students usually work in groups of two to three. In the BUGS program, mentors were included in the groups. The third stage reinforces the learning that has occurred. With the help of their mentor the students reflected on what happened during the activity, recorded their observations and data in a journal and discussed the results with their classmates and mentors. Finally, the students applied what they have learned to a real life situation and to other parts of the curriculum. The STC curriculum addresses National Science Education Standards.

The essential design of the evaluation for the initial study was the purposeful quasi-experimental. The BUGS group participated in the study, working closely with female mentors from TAMS and American Association of University Women (AAUW) throughout the program. The contrast group did not receive any treatment or support. Both groups were recruited through parent letters, contacts, and applications and were assessed in a pre- and post-test fashion.

Follow-up Study

Fourteen former BUGS participants were surveyed and their responses were compared to various contrast groups. The all-female contrast groups consisted of 12 original BUGS contrast students, 10 female science major students in their senior year of studies at a large Texas university, 10 general studies college students in their freshman year of college, and 9 STEM professionals. The 10 general studies majors had indicated that elementary education was their intended area of study. These students were included in the study to allow for a comparison between BUGS participants and the future teachers who might actual teach students similar to BUGS participants. The BUGS participants and contrasts were located through a combination of snowball sampling and use of the "find a friend" tool in Facebook, an online social network. Facebook was founded in 2004 and originally served as a social networking utility for college students. Although Facebook is no longer limited to college students, users between 18 and 24 years old still comprise the majority of Facebook's population, making it ideal for locating college students (Smith 2010). A former BUGS participant assisted with recruiting other former participants and contrasts on Facebook.

For the Science Majors group, 10 female science majors in their junior or senior year of college were recruited from a preparatory class for the Medical College Admission Test

(MCAT) in a large-sized university in central Texas. The Non-Science Majors group included 10 students from a class of pre-service educators in a large-sized university in north Texas. Finally, nine adult females who are currently in a STEM career, who attended the Society for Information Technology and Teacher Education Conference (SITE) in South Carolina in March 2009, formed the STEM Professionals group for this follow-up study.

Instrumentation and Data Collection

In the initial study, the Iowa Test of Basic Skills—Science (ITBS-S) was administered as a pre- and post-intervention measurement of basic science knowledge and skills. The test is 37 items long and yields a total raw score. The test is leveled for grade 5.

The follow-up study assessed participants with the STEM Semantics Survey (SSS) and the Career Interest Questionnaire (CIQ) to understand BUGS participants' actual perceptions of science and interest of their future STEM careers 6 years after the original study. Both instruments are intended to serve as major indicators for perceptions of STEM disciplines and careers.

SSS was adapted from Knezek and Christensen (1998) Teacher's Attitudes Toward Information Technology Questionnaire (TAT). On the SSS, participants use a semantic differential scale (ranging from 1 to 7) to indicate how they feel about five different topics: science, math, engineering, technology, and STEM careers. Because the BUGS program targets science, only the science and career subscales were used in this study. Figure 1 shows the science subscale of the SSS. The STEM careers subscale is similar, but the order of adjective pairs is randomized.

The Career Interest Questionnaire (CIQ) is a 5 point Likert-type (1 = strongly disagree to 5 = strongly agree) instrument composed of 12 items on three subscales. This instrument was adapted from a longer instrument developed for a Native Hawaiian Studies project promoting STEM interest in Hawaii. Adaptations of the instrument were based on a comprehensive analysis completed by Bowdich (2009). The CIQ items, divided by subscale, are as follows:

Part 1: Interest

- I would like to have a career in science
- My family is interested in the science courses I take.
- I would enjoy a career in science.
- My family has encouraged me to study science.

Part 2: Intent

- I will make it into a good college and major in an area needed for a career in science.
- I will graduate with a college degree in a major area needed for a career in science.
- I will have a successful professional career and make substantial scientific contributions.
- I will get a job in a science-related area.
- Some day when I tell others about my career, they will respect me for doing scientific work.

Part 3: Perception

- A career in science would enable me to work with others in meaningful ways.
- Scientists make a meaningful difference in the world.
- Having a career in science would be challenging.

Both instruments were analyzed as part of a validity study separate from this study and found to have respectable to excellent internal consistency reliability, as well as good content, construct, and criterion-related validity for the areas assessed (Tyler-Wood et al. 2010). Reliability estimates for both instruments are reported in Tables 1 and 2. Guidelines by DeVellis (1991) for assessing internal consistency reliabilities are shown in Table 3.

The reliability of two instruments ranged from .78 to .94 across the 5 constructs. These numbers are in the range of "respectable" to "excellent" according to DeVellis' guidelines.

Instructions: Choose one circle between each adjective pair to indicate how you feel about the object.

To me, SCIENCE is:

1.	fascinating	1	2	3	4	5	6	7	mundane
2.	appealing	1	2	3	4	5	6	7	unappealing
3.	exciting	1	2	3	4	5	6	7	unexciting
4.	means nothing	1	2	3	4	5	6	7	means a lot
5.	boring	1	2	3	4	5	6	7	interesting

Fig. 1 Science subscale of the STEM semantics survey

Table 1 Internal consistency reliabilities for STEM semantics survey scales

Scale	Number of items	Alpha
Science	5	.84
STEM Career	5	.93

Table 2 Internal consistency reliabilities for career interest questionnaire scales

Scale	Number of Items	Alpha
Interest	4	.86
Intent	5	.94
Perception	3	.78

Table 3 DeVellis reliability guidelines

Below .60	Unacceptable
Between .60 and .65	Undesirable
Between .65 and .70	Minimally acceptable
Between .70 and .80	Respectable
Between .80 and .90	Very good
Much above .90	Excellent (consider shortening the scale)

DeVellis (1991, p. 85)

Results

Initial Study: Did the BUGS Program Increase the Academic Achievement of 4th and 5th Grade Girls in Science?

A repeated measures analysis of variance revealed that the BUGS group made significantly higher gains on the ITBS-S pre to post than the BUGS Contrast group (F = 14.985, $p < .001$). Furthermore, as shown in Table 4, the BUGS group made significant gains pre to post, whereas the contrast group did not make significant gains. This quantitative data indicates that participation in the BUGS program, which provided the participants opportunities of authentic environmental experiences such as outdoor and indoor lab opportunities, simulation, trips and experiments, yields significant improvement in the BUGS participants' science achievement. This result reinforces the literature and current learning theory supporting the benefits of authentic experiences to the students' learning.

Follow-up Study: Do 4th and 5th Grade BUGS Participants have Positive Perceptions of Scientific Disciplines and Interest in Future STEM Careers Now that they have Completed High School and Entered College?

Results of a one-way ANOVA for the five comparison groups in both the Science and Career subscales of the STEM Semantics Survey are shown below in Table 5. Non-Science Majors had significantly less positive perceptions of science than the other four groups. No other post-hoc differences were found on the Science subscale, indicating that while BUGS participants ($M = 6.59$, SD = .326) have more positive perceptions of science than Non-Science Majors, their perceptions did not significantly differ from those of the Science Majors, STEM Professionals, and the BUGS contrast group. The BUGS group scored significantly higher ($p = .000$, Cohen's $d = 2.7$) than the regular college group ($M = 4.84$, SD = .853) in perceptions of science. In the career subscale, the BUGS group ($M = 6.44$, SD = .403) scored significantly higher ($p = .000$, Cohen's $d = 2.2$) than the regular college group ($M = 4.44$, SD = 1.23) and the BUGS contrast group ($M = 5.02$, SD = 1.23; $p = .001$, Cohen's $d = 1.47$).

Figure 2 graphically demonstrates that Science Majors (Group 2) have the highest positive perceptions on both science ($M = 6.88$, SD = .140) and career ($M = 6.56$, SD = .386). BUGS participants were the second highest, followed by STEM professionals, BUGS controls, and non-science majors.

Since STEM professionals are already in STEM careers, they were excluded from the analysis of the Career Interest Questionnaire (CIQ). Therefore, only BUGS, BUGS Contrasts, Science Majors, and Non-Science Majors are presented in the following results. A one-way ANOVA was performed on the Interest, Intent, and Perceptions subscales of the CIQ. Table 6 indicates that, analogous to the SSS, Science Majors have the highest interest in a science career (Part 1, $M = 4.65$, SD = .337), followed by the BUGS group ($M = 4.54$, SD = .378). Non-Science Majors

Table 4 Paired t-test results for ITBS-S for BUGS participants and controls

Subscale	Mean 1 (pre)	Mean 2 (post)	*t*	*df*	*p*	Effect size (Cohen's *d*)
BUGS Participants	23.03 (6.34)	29.03 (7.45)	−6.29	31	<.001	−1.13
Controls	24.06 (5.98)	25.03 (7.91)	−1.10	33	.28	–

Standard deviations appear in parentheses below means

Table 5 A comparison of mean scores among groups completing the STEM semantics survey

	Comparison Groups									
	Group 1: BUGS n = 14		Group 2: Science Majors n = 10		Group 3: Non-Science Majors n = 10		Group 4: STEM professionals n = 9		Group 5: BUGS contrasts n = 12	
SSS Subscale	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Science	6.59	.326	6.88	.140	4.84*	.853	6.33	1.00	6.08	.726
Career	6.44	.403	6.56	.386	4.44**	1.23	6.20	.843	5.02**	1.23

* Significantly lower scores when compared to Groups 1, 2, 4, and 5; ** significantly lower scores when compared to Groups 1, 2, and 4

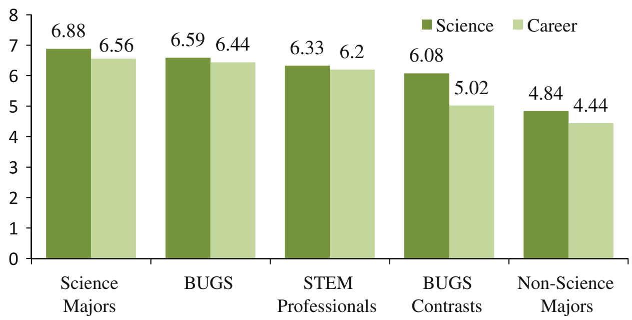

Fig. 2 Semantic perceptions of five groups toward science and career

(M = 3.23, SD = .399) have the lowest interest in pursuing a science career in the future. The BUGS group scores outperformed Non-Science Majors and the BUGS contrast group, which suggests the BUGS group has higher science career interest for their future.

Discussion

It was an important goal of the BUGS program to not only bring about short term academic gain, but to influence girls' perceptions of science and increase their placement in STEM careers. Gains in academic achievement are evident as the BUGS participants in the initial study made significantly greater gains on the ITBS-S pre- to post-test than the contrast group. While the eventual career paths of the children involved in BUGS are certainly unknown, data clearly indicate that the majority of these girls now have a much stronger awareness, appreciation, and confidence with science. The final results of this impact will likely not be noted until much later in the girls' lives.

There are some limitations associated with the current study. The sample size is small (32 original participants). Less than half of the original BUGS participants completed the follow-up surveys. Such limitations call into question the generalizability of the current study. In addition, there is a possibility that the increase in science knowledge and interest is simply a result of additional exposure to science subject matter and the results reported are not necessarily related specifically to participation in the BUGS program. Also, the BUGS program infused many components which included: mentoring, an afterschool program, a summer program, and an increased exposure to the STC curriculum which is based on National Science Education Standards. The methodology provided by the current study does not present an opportunity to determine how the BUGS program components interact and which component is most effective. Future research on the BUGS program should address these concerns.

When reviewing STEM perceptions among the measured groups, it is of concern that the future education majors scored so low in their perceptions of science. It would seem important to conduct additional research to determine the role that a teacher's perception of science

Table 6 A comparison of mean scores among groups completing the career interest questionnaire

	Comparison Groups									
	Group 1: BUGS n = 14		Group 2: Science Majors n = 10		Group 3: Non-Science Majors n = 10		Group 4: STEM professionals n = 9		Group 5: BUGS contrasts n = 12	
CIQ Subscale	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Interest	4.54	.378	4.65	.337	3.23*	.399	–	–	3.79*	.745
Intent	4.37	.302	4.64	.280	2.20**	2.38	–	–	3.48***	.463
Perception	4.60	.325	4.77	.316	2.57**	.610	–	–	3.75***	.669

* Significantly lower scores ($p < .001$) when compared to BUGS and Science Majors. ** Significantly lower scores ($p < .001$) when compared to BUGS, Science Majors, and BUGS Contrast Group. *** Significantly lower ($p < .001$) when compared to BUGS and Science Majors, but significantly higher ($p < .001$) than the Non-Science Majors

plays in student achievement in science and subsequent STEM related career choices.

Self-efficacy represents a student's perceived ability to perform actions necessary to attain a specific given outcome (Bandura 1977). Self-efficacy may be a good indicator of whether the BUGS participants will continue to pursue scientific coursework and careers. The STEM Semantic Survey and the Career Interest Questionnaire can be used as measures of self-efficacy. Pajares (1996) noted that self-efficacy measures should possess both measurement specificity and congruence with the behaviors in consideration. The instruments in the current study meet Pajares specifications. The STEM Semantic Survey and the Career Interest Questionnaire provide empirically developed assessments of students' self-efficacy for performance in science courses and activities. To further validate the instruments as effective measures of self-efficacy, it will be important to continue to follow the BUGS participants as they select a career to determine if an early intervention program can increase self-efficacy in science and if that increase eventually results in more female students selecting science careers.

Follow-up studies, although rarely sponsored by funding agencies, are critical to determine long term program effectiveness. The current study is an attempt to show that an effective science program for girls at the elementary level can make a difference in the way young females view science and STEM careers as they enter college. It will be important to continue to follow BUGS participants to determine if indeed these young women pursue careers in STEM.

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