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Gender Differences in Student Attitudes towards Science in Secondary School Classrooms with and without NSF GK-12 Resident Scientists

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ABSTRACT

The purpose of this three-year study was to examine middle school female and male students' attitudes about science in four different categories before and after being with PhD science graduate students, *resident scientists,* in their classrooms every week. The study was based upon a National Science Foundation (NSF) program called *Project Flowing Waters,* a five-year NSF Graduate STEM Fellows in K-12 Education (GK-12) program. This study covers the final two years of the program, Year 4, Year 5, and also includes a control year, Year 6, that occurred after the program and thus, lacked resident scientists. In Year 4 and 5, the program funded 17 doctoral students, known as NSF GK-12 fellows, who served as bi-weekly resident scientists in science classrooms in local schools. A newly developed science attitude survey, *My Attitude Toward Science Scale* (MATS) (Hillman, Zeeman, Tilburg & List 2016) was used to survey student attitudes in four categories. Matched pre- and post- student attitude surveys were obtained. Seventeen resident scientist/teacher partnerships were analyzed, involving [n=1075 students] in the 2011/12 (Year 4) and 2012/13 (Year 5) school years and 366 students in 2015/16 (Year 6-Control) school years using the survey. Results indicated significant gender differences in attitudes only in Year 5, with male students being more positive than female students about their attitudes towards science, desire to be a scientist, value of science to society and holding less stereotypical perceptions of scientists.

Introduction

Historically, science has been a male dominated field (NSF, 1988). The representation of women in science in the last twenty years in the United States has been slowly increasing, particularly in the life sciences. For example, for U.S citizens in 2000, women earned 43% of all science and engineering (S&E) master's degrees and by 2015, they earned 50% of S&E master's degrees awarded (S&E Indicators, 2018). In 2015, both the STEM bachelor's and master's degrees earned by women were primarily in the biological sciences. At the doctoral level, in 2015, 51% of the S&E doctoral degrees were awarded to women which is an increase of 45% in 2000. Of those doctoral degrees awarded to women in 2015, over half of these were in the biological sciences, and in the medical and health sciences (National Science Board/Science & Engineering Indicators, 2016). There is still gender disparity in doctorates earned by women in the physical sciences. Although, more women earned S&E

degrees in 2015 than in 2000, there has been little change in the percent of those working in S&E occupations except in the biological sciences. Women are still underrepresented in the other Science, Technology, Engineering and Mathematics [STEM] occupations. Only 28% of women were working in S&E occupations in 2015. However, gender parity has been reached in biology; in 2015, women represented 48% of life scientists (S&E Indicators, 2018) . In a recent review of gender bias in the science work place, Grogan (2018) stated that unconscious gender bias may contribute to disparity in scientific communities including: bias with peer reviewers, recommendations, hiring processes, collaborations, and recognition. Other researchers have attributed this gender bias or disparity to certain complex factors that include: inequity in manuscript reviewing, grant funding and opportunities available to study and work in the discipline (Ceci & Williams, 2011). According to Blickenstaff (2005), if women were given the opportunity, they could help to solve problems in STEM endeavors, and contribute to a greater diversity of perspectives in finding solutions.

In K-12 education, there is a close relationship between student attitudes toward science and students' achievement in science, and due to this, the attitudes of students toward science is vital to the economic health of the society (National Center for Education Statistics, 2011). It has been shown that students that do well in mathematics and science have a positive attitude toward science, and this allows them to successfully complete advanced courses in mathematics and science (Bae et al. 1997). Having a population that has scientific literacy is imperative to a nation's ability to solve complex issues. Therefore, engaging students in science, both male and female, is critical to the nation's stability (National Center for Education Statistics, 2011).

Gender disparity in the STEM fields may have its origin in general societal beliefs about gender roles and in the formal K-12 public education through the practice of gender bias. Reinking and Martin (2018) summarized three theories as to why there is a gender gap in STEM in societies. These theories include 1) general societal stereotypes such as boys being *good in math* and girls being *good in the kitchen*, 2) peer group influences and 3) professional stereotypes of scientists as being socially ackward or introverted. Cultural beliefs that women should be socially outgoing is in conflict with the professional stereotype of a scientists. Researchers have noted gender bias in teachers towards their students as early as the elementary school years. In one study, by Gunderson et al. (2011) teachers praised their male students' successes more and attributed them to the students' ability in mathematics. In the case of their female counterparts, the teachers attributed their successes to effort or luck. As a result, female students feared that they would do poorly on a math test. This supported their hypothesis that girls felt that they were less skilled in math than the male students.

Blickenstaff (2005) suggested that having female role models may help to address the problem of female underrepresentation in science occupations. He suggested that having female role models in the classroom could help to inspire talented young women to pursue science related studies. Blickenstaff (2005) focused on the role of gender in students' science choices and perspectives. His study emphasized the need for more female role models in K-12 classrooms. More recently, Steinke (2017) explored role modeling in regards to the role of STEM identity formation or " perceptions of one's self as a scientist" (para 15). In her research, she examined the influence of media models of STEM professionals on adolescent girl STEM identity formation . Many factors, beyond simply seeing a female role model scientist on the screen, are involved in whether an adolescent female will embrace a STEM identity. Some of those factors include relationships with family, friends and their teachers (Steinke, 2017). The complexity in understanding STEM identity formation and attitudes towards science was succintly stated by Kang et. al (2018) in their research on STEM identity formation in the middle school years, "We, as a field, have just begun to recognize and understand the complexity of studying youth forming senses of self in STEM during middle school" (p. 435). The focus of our study was to see the effect of having real female scientists, not actors on the screen, interacting with middle school girls every week for an entire school year and whether this would help to close the gender gap between females and males in terms of their attitudes towards science.

Background of Study

The outreach component of the National Science Foundation's (NSF) Graduate STEM Fellows in K-12 Education Program (NSF GK-12) was created to support K-12 teachers and students in the STEM field using inquiry-based learning activities (National Science Foundation, 2007). Students and teachers had opportunities in GK-12 programs to develop a broader knowledge in STEM fields. The main purpose of the GK-12 programs were to prepare science graduate students to become future science professors and to improve their communication and team building skills. The Texas State University Biology Department selected PhD graduate student fellows in science to participate in their NSF GK-12 program, *Project Flowing Waters.* The outreach component of the program was a five-year study examining secondary students' attitudes towards science before and after they had spent an entire year with a resident scientist in their classroom. Resident scientists were trained in inquiry-based science teaching using the 5E instruction-teaching model (Bybee, 2006). Resident scientists partnered with science teachers in a local school district. The training was designed to help resident scientists develop 5E lessons that were aligned with Texas Essential Knowledge and Skills (TEKS). These lessons met the criteria for specific grade levels and the resident scientists visited the classroom for 10 hours each week for the entire school year (Dame & Westerlund, 2015, p. 10). The resident scientists provided students in the 6th- 8th grades with inquiry-based learning experiences and engaged them in-depth discussions in small groups of both genders. For example, at one of the middle schools, there was a stock tank behind the school. The resident scientists created inquiry lessons concerning not only identification of pond organisms but a long term study of the ecosystem around the pond. Field trips to the pond were exciting to the students and to the principal who had a dock built for their studies! In Year 4, each program teacher was partnered with a resident scientist. Students that had program teachers became very familiar with their teachers' partnered resident scientists. In Year 5, the resident scientists were still partnered with a program teacher but more flexibility was put in so that resident scientists could pair up or act as a team when presenting lessons. This change was implemented to encourage collaboration at each of the middle schools and so that resident scientists could work more easilty in smaller groups of students. As a result of the change, students in Year 5 had less interaction as a whole class with their particular teachers' partnered resident scientists. The lessons took place indoors and outdoors in various locations, including Bastrop State Park and the Blanco River.

In the first 3 years of this NSF GK-12 program, at the beginning and at the end of the school year, the resident scientists administered the *Student Attitudes about Science* (SASI) survey to survey student attitudes about science (Dame & Westerlund, 2015). Within the first three years of *Project Flowing Waters*, student attitudes were examined in three main categories: 1) Science and scientists, 2) Student abilities in science and 3) Importance and usefulness of science. The results indicated that in the category *Science and scientists*, there were significant differences between the pre-and post-surveys with improved student attitudes. In the category *Student abilities in science*, there was a positive change in students' attitude in only one of the 24 partnerships. Lastly, in the category *Importance and usefulness of science*, there were no significant changes in student attitudes. Overall, the (Dame & Westerlund, 2015, p. 24) study indicated that having resident scientists in classrooms only changed students' attitudes towards *Science and scientists* and not towards their *Student abilities in science* or the *Usefulness of science.*

To examine further the effects of resident scientists on student attitudes, in terms of gender differences, our present study used a different survey tool, *My Attitudes Towards Science* (MATS). Hillman et al. (2016) developed the MATS survey and it included four categories:

1) The subject of science
2) The desire to become a scientist
3) The value of science to the society
4) The perception of scientists (Hillman et al. 2016).

Purpose of Research

The purpose of our research is to examine student gender differences using the four categories of the MATS to examine whether having or not having resident scientists in their classrooms could influence secondary students' attitudes in four categories; the subject of science, students' desire to become scientists, the value of science to society, and students' perceptions of scientists.

Research Question

Are there gender differences in student attitudes on the four categories of the MATS survey in classes with and without resident scientists?

Null hypothesis

There is no significant difference in the male and female students' attitudes toward science in the four MATS attitude categories in classes with and without resident scientists.

Literature Review

Definition of Student Attitude

Freedman (1997) defined student attitudes as the students' perceptions of their own abilities to achieve in science. Schibeci (1983) noted that student attitudes were associated with various factors: science classes, work in the lab, the teacher's motivation, and the student's gender. Saleh & Chine (2011) agreed that various factors influence students' attitudes towards science, but that motivation was one of the most significant influences. In their study, they found that project-based learning increased motivation with resulting improvement in student attitudes towards science. According to Ryan & Deci (2000), student interest in science is largely based on motivation, both intrinsic and extrinsic. Once the student is intrinsically motivated, the student's enjoyment and satisfaction in learning science comes naturally. However, when a student is extrinsically motivated, there is no desire or enjoyment in learning science. External rewards are then required for the student to participate fully in the learning experience. Recent studies in this area of attitudes towards STEM include research in STEM *identity formation* (Kim et al., 2018) and a *sense of belonging* to the STEM field (Rainey et al. 2018).

Factors Influencing Student Attitudes towards Science

There are a variety of factors that may influence females to dislike science. The gender gap between males and female attitudes about STEM has been attributed to factors involving socialization.

Socialization practices in the United States and stereotypes of scientists may play a significant role (Reinkin and Martin (2017). First, in terms of socialization, the influence of parents can influence a student's attitudes towards science. Secondly, the influence of peer groups during the academic experience is another reason to dissuade females from considering science because students tend to engage in activities of their peer groups (Reinkin and Martin (2017). Earlier work by George (2000) found that females may have a negative mindset towards science and science careers beginning at home from their mothers' influences that science is not suitable for women. In an another early large-scale study with 1,200 students, researchers found that differences between male and female attitudes towards science occurred early in middle school. This acted as a strong predictor of student attitudes towards science in general (Weinburgh, 2000). However, Kahle & Lakes (1983) reported that negative female attitudes towards science actually begins earlier, in the elementary grades. In these early grades, girls viewed science classes as "facts to memorize, and boring" (Kahle & Lakes, 1983, p.131). Furthermore, Kahle & Lakes (1983) showed that, in schools, teachers placed different values on students according to their gender. Male students were "valued for thinking logically, independently, with self- confidence and an appropriate degree of risk taking" (Kahle & Lakes, 1983, p.131) which are typical values found in science. On the other, female students were "valued for their emotional expressiveness, sensitivity to others, dependency and subjective thinking" (Kahle & Lakes, 1983, p.131). These early studies, such as George (2000) and Kahle & Lakes (1983) have been supported by later research in this area. For example, Rainey et al. (2018) described that a student's sense of belonging in the STEM fields is related to interpersonal relationships including family and friends. And, Ceci et al.(2014) reported that gender differences in attitude are apparent even in kindergarten. The perception of a scientist is a factor that may also contribute to student attitudes about science. Saleh & Chire (2011) noted that students' perceptions of scientists can negatively impact their attitudes about science by showing that scientists are similar, *type-cast.* individuals. They brought to light, through their research, that there is a common theoretical and practical stereotypical perception of scientists across "all grade levels, genders, ethnic groups and national boundaries" of students. Debacker & Nelson (2000) also showed the uniformity of the perception of scientists when they gave students the task of drawing a picture of a scientist. Both male and female students portrayed scientists as males who worked in a lab and wore white coats and glasses. These results indicated that both males and females have stereotypical images of scientists. This has been a consistent stereotypical view at least since the mid-60s. Over a period of 11 years from 1966 to 1977, Chambers (1983) created and administered the Draw-a-Scientist Test (DAST). His results from extensive testing revealed that the stereotypical views of a scientist occurred earlier than high school and became progressively more stereotypical as students become older (Chambers, 1983, p. 264).

Conscious and Unconscious Gender Biases of Teachers

Teachers in classrooms have unwittingly shown unconscious gender bias towards their students and this has affected their teaching practices (Bailey et al. ,1997, Kim et al. 2018). In the science classroom, teachers give boys more frequent opportunities to answer questions and more positive feedback than girls in the same classroom (Greenfield, 1996). According to Lavy & Sand (2015), teachers see boys as having more financial value to the society, and therefore reinforce the concept that science is a subject for boys. The stereotypical attitude of teachers toward their male and female students where girls are treated differently affects students' self-images and confidence. Teachers with this bias give fewer opportunities for girls to participate in science classes, encouraging boys to try harder and giving more time for them to respond in class. This custom in the classroom has impacted negatively on female students' perception of science. Lavy & Sand (2015) confirmed teacher gender bias in a study conducted in Israel and found that teachers were *conscious and unconscious* in their bias towards their female students. The teachers favored boys, and this may have led to males having a positive attitude towards math and science. Girls in this study, on the other hand, had negative attitudes towards math and science. In their study, Lavy & Sand (2015) compared the scores of external evaluators and classroom teachers who graded the same examinations. In instances where classroom teachers graded the exam, male students scored higher than the female students. However, when the external evaluators graded the same exam, female students actually scored significantly higher than boys (Lavy & Sand, 2015). This indicated a possible gender bias on the part of the teachers.

Conceptual Framework

To form our conceptual framework that female student interest in science is influenced by others, including resident scientists, we examined studies about how female student interest in the science is built through female scientist role models and through influential peers that are interested in science.

Secondary students who interact with scientists can develop a positive attitude towards science and scientists. In one research study, students in an after-school robotics program worked with scientists to build a Robot for a competition (Saleh & Chine, 2011). Researchers compared the attitudes of students in an after-school robotics program with that of other students from the same school that did not participate in the after-school program. Pre and posttest measurements of student attitudes toward science using the Test of Science Related Attitudes (TOSRA) revealed that students that participated in the program showed a significantly more positive attitude toward scientists and science than those that did not participate (Saleh & Chine, 2011). However, in an earlier 2002 study (Buck et al. 2002) indicated that when female scientists were brought into elementary classrooms for four 45 minute visits, there was no change in the elementary students' perceptions that scientists were males. It is not clear whether a more sustained approach with twice a week visits by scientists, including female scientists, for an entire school year might have more of an effect on female student attitudes.

Kim et al. (2018) in his review of peer studies suggested that female students experienced the benefits of seeing other girls (their peers) who are interested in math and science as well as meeting female researchers and scientists who are doing work in the STEM fields of their interest. Our program demonstrates the critical value of exposing young women to other young women who are interested in STEM as well as successful female scientists and researchers. In social identity terms, consistent exposure of young women to female role models can foster perceptions that female interest and success in STEM are not rare and atypical but normal. Over time, this has the potential to change perceptions regarding who is in the STEM fields from being predominantly male to being more gender-even.

Theoretical Framework

The theoretical framework we propose to support our conceptual framework is that inquiry science teaching, that is emphasized in lesson designs for the middle schools in this program, promotes student interest in science due to the theory of *constructivism* (Ismat, 1998). Inquiry science teaching is based upon constructivist epistemology. In constructivism, individuals "construct" understanding or new knowledge based upon what they already know from their own life experiences. To have students become *involved* with new content, instructional *constructivist* strategies were used that included the 5 E teaching methods (Bybee et al. 2006). All resident scientists were trained in the 5 E teaching method to promote inquiry science teaching in their lessons

Methods

Research Design

Project Flowing Waters program was an interdisciplinary National Science Foundation (NSF) Graduate STEM Fellows in K-12 Education (GK-12) program. STEM refers to Science, Technology, Engineering and Mathematics. The project represented a collaboration of two middle schools in a local school district and the Texas State University Biology Department. The Institutional Review Board (IRB) granted IRB Exemption 13-59394 for human subjects research prior to the inception of the study. In accordance with IRB, all parents of the students involved in the study were provided with consent letters, in English and Spanish, labeled with IRB approval number #2008-62370. The backdrop of the project was the watershed of the San Marcos River River reflected in the name *Project Flowing Waters*. Care of the watershed provided the impetus for scientific study in the interdisciplinary areas: such as aquatic biology, aquatic ecology, conservation biology, and river restoration. The main goals of the program as stated in their annual reports to NSF were: (1) To improve the communication, collaboration teaching and team building skills of resident scientists, (2) to provide professional development opportunities for 6^{th} – 12^{th} grade science teachers, (3) to increase student interest in the STEM areas, (4) to strengthen the partnership between Texas State University and a local school district, and (5) to instill a deeper understanding of inquiry-based science teaching into Texas State graduate programs and provide opportunities to practice these approaches (National Science Foundation, 2013, p. 1). In this study, the focus is on the third goal; to increase student interest in the STEM areas.

Sample Demographics

The schools that participated in this GK-12 program were Gracet Middle School and Merriweather Middle School (pseudonyms in accordance with IRB regulations). Gracet Middle School had an enrollment of 1011 students in 2013. The population of Gracet was 72.9% economically disadvantaged, with 7% being English language learners. Merriweather Middle School had a population of 725 in 2013. The population of Merriweather was 69.8 % economically disadvantaged in 2013, with 3.7% being English-language learners as obtained from the Texas Education Agency records. The number of male and female students and resident scientists that participated in the study are shown in Table 1.

Table 1. *Demographics of Sample*

Year	Number of Male Students	Number of Female Students	Number of Male Resident Scientists	Number of Female Resident Scientists
11/12 (Year 4)	145	125	4	4
12/13 (Year 5)	378	427	6	3
15/16 (Year 6*)	208	158	0	0

Note: Sample sizes of male and female students and resident scientists in the three years of the study program. *Control

Survey Instrument

Dr. Susan Hillman at University of England in Biddeford, Maine developed an instrument to analyze student attitudes towards science, and provided evidence of the reliability and validity of scores produced by this instrument (Hillman et al., 2016). The resulting survey, titled *My Attitudes towards Science* (MATS) consists of 40 negative and positive statements in four categories: (1) Attitude Towards the Subject of Science; (2) Desire to Become a Scientist; (3) Value of Science to Society; and (4) Perception of Scientists. Participants respond using a five-point Likert scale. This survey can be used across several grade levels and can be either hand or machine scored. This MATS instrument (Appendix) was used in the present study to measure these four aspects of students' attitudes towards science.

Time frame of the Project Flowing Waters program & Participant selection

The Project Flowing Waters program was initiated in 2008 and ended in 2013. Grades served in this GK-12 program ranged from middle school to high school. In this study, we examined middle school student attitudes in the final two years of the program and a control year. PhD biology students were selected to become GK-12 Fellows (known as resident scientists) based on an application process. Their selection into the program was based upon numerous factors including publication within their scientific fields. Selected resident scientists were given a stipend and tuition assistance to serve as resident scientists in the program. Classroom teachers who participated in the program went through a selection process and were provided with a stipend. Once the classroom teachers accepted the offer to participate in the program, parents of their students were given a letter requesting permission for their child to participate in the program.

Research Procedures and Data Collection

Resident scientists were trained in inquiry-based teaching using the 5E method (Bybee et al., 2006) in the summer prior to the school year. The resident scientists were paired based upon the research area of the resident scientist and the subject area of the class that the teachers taught so that the resident scientist could bring his or her expertise to the classroom. The resident scientist spent approximately 10 hours each week in the classroom and several hours outside of the class preparing lessons. In the 2012-13 year, resident scientists worked together in teams that visited different classrooms. Each classroom saw both male and female resident scientists. The resident scientists developed lessons with engagement in mind and designed for inside and outside of the classroom.
Each year, teachers and resident scientists were paired together in schools. There was a fairly even representation of male and female teachers in all three years. In Year 4 (n = 270 students), eight teachers participated in Project Flowing Waters, four males and four females. In Year 5 (n = 805 students), there were five female teachers and four male teachers. In Year 6, control year (n = 366 students), there were two male and two female teachers from the original program that participated. There were no resident scientists in Year 6, the control year.

At the beginning of the school year, in September, students were given a pretest MATS survey. And at the end of the school year, in April, students were given a posttest MATS survey. The survey was hand-scored to increase the quality of the data and provide more accurate responses and pre/post surveys were matched per student .Data for the last two years, 2011/12 and 2012/13, was collected with a total sample size of 1075. Control data was collected in 2015/16 with a sample size of 366 to compare whether or not the intervention of having resident scientists working with classroom teachers made a difference in students' attitudes. All of the teachers in the control sample were previous Project Flowing Waters program teachers.

Statistical Analysis

The students' pre-and post- MATS surveys were analyzed to evaluate whether the gender of the student influenced their attitudes in the four MATS. Independent samples two-tailed t-tests using SPSS statistical software ("SPSS Software, "n.d.) and GraphPad statistical software ("GraphPad QuickCalcs: t test calculator, "n.d.) were conducted to test for gender differences. The two tailed t-tests were chosen because they are useful in detecting significant differences between two samples; the pre and the post-MATS surveys.

Results

Comparisons of male versus female students are presented by year and MATS category with resident scientists (Years 4 and 5) and without resident scientists (Year 6). Table 2 presents the results concerning gender differences in the category *student attitudes towards science* over the program years and the control year. There are significant differences in Year 5 between male and female student attitudes. Although, the Cohen's d effect size is small.

Table 2. *Students' Attitudes towards Science-Independent samples t-test*

Year	Gender	N	M	SD	t	p	Cohen's d
Year 4	Male-Pr	144	3.64	0.69	1.15	0.25	
	Fem-Pr	124	3.53	0.81			
	Male-Po	145	3.73	0.76	1.99	0.48	
	Fem- Po	125	3.55	0.78			
Year 5	Male-Pr	378	3.86	0.70	3.60	.00**	0.25
	Fem-Pr	427	3.68	0.76			
	Male-Po	377	3.59	0.64	3.60	.00**	0.26
	Fem-Po	427	3.42	0.69			
Year 6	Male-Pr	208	2.64	0.31	1.49	0.14	
	Fem-Pr	158	2.59	0.36			
	Male-Po	208	2.75	0.39	0.44	0.66	
	Fem-Po	158	2.73	0.39			

Note: Pr=Pre-MATS, Po=Post-MATS, Fem=Female
Statistical significance: *p ≤.05, **p≤.01

The results in Table 2 indicate that there were statistical differences between male and female students in Year 5 in both of the pre and post attitude surveys. Male students had significantly more positive attitudes towards science than female students before and after their experiences with resident scientists. The Cohen's d effect sizes are small for the significant differences.

Similar to Table 2, as shown in Tables 3, 4, and 5, only Year 5 appears to have significant differences between male and female students in the attitudes surveys. The significant difference again are associated with small Cohen's *d* effect size. The larger sample size of Year 5 (n=805) in comparison to Year 4 (n=270) and Year 6 (n= 366) may allow greater statistical power to detect small effects.

Table 3. *Students' Desire to be a Scientist-Independent samples t-test*

Year	Gender	N	M	SD	t	p	Cohen's d
Year 4	Male-Pr	145	2.73	1.13	1.67	0.98	
	Fem-Pr	126	2.50	1.07			
	Male-Po	145	2.80	1.16	1.89	0.06	
	Fem-Po	126	2.54	1.06			
Year 5	Male-Pr	380	2.82	1.08	1.57	0.12	
	Fem-Pr	428	2.70	1.13			
	Male-Po	380	2.70	1.11	2.1	0.03*	0.15
	Fem-Po	428	2.53	1.17			
Year 6	Male-Pr	208	2.53	0.62	0.654	0.51	
	Fem-Pr	158	2.48	0.73			
	Male-Po	208	2.54	0.63	-1.78	0.08	
	Fem-Po	158	2.66	0.67			

Note: Pr=Pre-MATS, Po=Post-MATS, Fem=Female
Statistical significance: *p ≤.05

The results in Table 3 indicated that there was statistical significance between male and female students in Year 5 in the post attitude surveys. Male students were more positive about their desire to be a scientist after being with resident scientists. The Cohen's d effect size is small for the significant difference.

Table 4. *Students' Value of Science to Society-Independent sample t-test*

Year	Gender	N	M	SD	t	p	Cohen's d
Year 4	Male-Pr	144	3.95	0.60	1.07	0.28	
	Fem-Pr	126	3.87	0.59			
	Male-Po	145	4.07	0.66	1.81	0.07	
	Fem-Po	126	3.93	0.58			
Year 5	Male-Pr	379	4.09	0.59	2.60	0.01*	0.18
	Fem-Pr	426	3.98	0.60			
	Male-Po	379	4.06	0.46	3.40	0.00*	0.22
	Fem-Po	427	3.96	0.45			
Year 6	Male-Pr	208	2.86	0.40	1.74	0.08	
	Fem-Pr	158	2.79	0.39			
	Male-Po	208	2.82	0.41	-0.14	0.89	
	Fem-Po	158	2.82	0.38			

Note: Pr=Pre-MATS, Po=Post-MATS, Fem=Female
Statistical significance: *p ≤.05, **p≤.01

The results in Table 4 indicate that there were statistical differences between male and female students in Year 5 in the pre and post attitude surveys. Male students had significantly more positive values of science to society than female students <u>before</u> and <u>after</u> their experiences with resident scientists. The Cohen's d effect sizes are small for the significant differences.

Table 5. *Students' Perceptions of Scientists-Independent samples t-test*

Year	Gender	N	M	SD	t	p	Cohen's d
Year 4	Male-Pr	145	2.48	0.51	0.22	0.83	
	Fem-Pr	126	2.49	0.44			
	Male-Po	144	2.29	0.53	1.44	0.15	
	Fem-Po	125	2.38	0.46			
Year 5	Male-Pr	378	2.33	0.48	1.80	0.07	
	Fem-Pr	428	2.39	0.48			
	Male-Po	380	2.21	0.46	2.50	0.01*	0.17
	Fem-Po	427	2.29	0.46			
Year 6	Male-Pr	208	2.50	0.44	-.004	0.10	
	Fem-Pr	158	2.37	0.41			
	Male-Po	208	2.36	0.51	0.85	0.39	
	Fem-Po	158	2.29	0.48			

Note: Pr=Pre-MATS, Po=Post-MATS, Fem=Female
Statistical significance: *p ≤.05, **p≤.01

The results in Table 5 indicated that there was statistical significance between male and female students in Year 5 in the post attitude surveys. Male students held less stereotypical views about scientists after being with resident scientists. The Cohen's d effect size is small for the significant difference.

Discussion

This study was based upon a collaboration between an NSF GK-12 program, university, and a local school district to provide inquiry science trained Texas State University PhD students for secondary school science classrooms. The research question was to determine if there were differences in students' attitudes towards science based upon the gender of the student. The attitudes towards science were categorized in four areas based upon the MATS surveys:

(1) The subject of science
(2) Desire to become scientists
(3) The value of science to society.
(4) Perceptions of scientists.

Based upon the research question, the null hypotheses was established to test the statistical significance of any gender difference in either the pre (September) and post (April) MATS surveys. The null hypotheses is that there is no significant difference between male and female students in the four attitude categories in the pre or post surveys. Overall, only results for Year 5 provided evidence that disputes the null hypotheses. However, it should be noted here that even with statistical significance between male and female student surveys in Year 5, the actual Cohen's d effect sizes were small. The significance may be an artifact of large sample sizes. These results will be described per category below.

Students' Attitudes towards Science

Based upon the overall results, there is no evidence indicating that having a resident scientist in the classroom may cause students to have more positive attitudes towards science. With respect to gender, in Year 5 (Table 2), there was a statistically significant difference between male and female students on both pre and post surveys concerning attitudes toward science. Male students had a better attitude towards science, which rejects the null hypothesis that there are no significant differences between male and female students' attitudes. In Year 4 and in Year 6 (Table 2), there were no significant differences between male and female students. Hence, there is not conclusive evidence indicating that having a resident scientist, including a female scientist, in the classroom may cause female students to have more positive attitudes towards science. However, in Year 4 and in Year 6, we did see a positive trend in attitudes from pre to post surveys. Although, the trend was not significant.

It is not surprising that male students would have more positive attitudes than female students since early studies indicated that science is a male dominated field (NSF, 1988). In this study, it was evident that male students have more positive attitudes towards science than female students. Despite the fact that some female students were exposed to female scientist role models in the classroom for a year, female student surveys were still significantly lower than male students in Year 5. This finding is supported by research by (George 2000) indicating that females may have a negative mindset towards science and science careers.

Students' Desire to Become Scientists

In Year 5, there was a significant difference between the genders on the post survey. Male students appeared to have a greater desire to become scientists than female students (See Table 3). The result in Year 5 indicated that male students have a greater desire to become scientists which rejects the null hypothesis that there is no difference in attitudes between the gender of students. Although, as shown earlier, the Cohen's d effect size is small. That boys have a greater desire to become scientists is supported in the literature. According to (Jones et al. 2000), both males and females report that science is difficult, but that science is more appealing for boys. There was no significant difference in Year 4 or in Year 6 between male and female pre and post surveys concerning the desire to become a scientist. This was surprising with the recent results of Steinke & Taverez (2017) on the importance of female role models in science and Kang et al. (2019) and Kim et al. (2018) on STEM identity formation. Again, the results are inconclusive as to whether male and female students are different with respect to their desire to become scientists since both Year 4 (with a resident scientist) and Year 6 (without a resident scientist) showed no significance.

The Value of Science to Society

There was a significant change, with a small Cohen's d effect size, with respect to gender, in Year 5, between pre and post surveys (Table 4). Male students had more positive attitudes concerning the value of science to society. This rejects the null hypothesis that gender has no effect on students' desires to be a scientist. However, significance was not seen in Year 4 or in Year 6.

Perception of Scientists

There was a significant difference between male and female student attitudes, again in Year 5, but not in Year 4 or in Year 6 (See Table 5) with respect to their perceptions of scientists.
In regard to gender between male and female students, females had less stereotypical views than male students (shown as smaller values), although not significant in Year 4 and in Year 6. On the MATS survey, the smaller the value in this category, the less stereotypical the perceptions of scientists. Studies

have showed that, regardless of gender, male and female students view scientists as stereotypes. (Saleh & Chine, 2011). Nevertheless, in this study, the results indicated that over both Years 4, 5 and Year 6 , students has less stereotypical views of scientists by the end of the year. This result makes sense in light Steinke (2017) research who studied the importance of role modeling, in this case female resident scientists, in regards to the role of STEM identity formation. However, it is surprising that we saw that students had less stereotypical views of scientists even within classrooms without scientists in the control year, Year 6.

Unexpected Results of the Study

This research has discovered unusual results in one of the four MATS categories that were examined during Year 6 which did not have resident scientists. It is surprising that student perceptions of scientists had improved with less stereotypical views within traditional classrooms without resident scientists. Perhaps the inquiry science teaching and the real-world applications in science that were emphasized in the Project Flowing Waters program in their school curriculum in Years 4 and 5 may have been implemented even without resident scientists in Year 6 in their classrooms. Year 6 had the original Project Flowing Waters program teachers that had worked with resident scientists in their classrooms in previous years. Perhaps, there was a carry-over of the program into the control year. It is possible that the four teachers in Year 6 described scientists in non-stereotypical ways with their students due to their collaborations with resident scientists in earlier years.

Implications of the Study

First Implication

Results from our study indicated that male students' MATS scores tended to be different than female students in the categories, with significance in Year 5. This indicates that plans should be implemented to overcome this gender disparity. This gender disparity was unexpected in a GK-12 program that had female science PhD students serving as female role models in the classroom 10 hours a week. Even GK-12 type programs need to be more proactive in involving female students in science. It is not enough to simply provide female role models. Greenfield (1996) indicated that boys had more opportunities to answer questions and receive more feedback than girls. Perhaps that gender disparity in communication played a role in our GK-12 program. Hence, it may be a good strategy in GK-12 type programs to train teachers and resident scientists to call on girls more often or pair girls up to work with other girls. Teachers should mindful that girls are less positive about science and may need more encouragement than boys.

Second Implication

The role of a parent, a child's first and primary teacher, in their daughters' interests in math and science needs to be addressed (Gunderson et al., 2011). If female science attitudes are to be changed, GK-12 type programs may need to involve parents more so than simply signing a letter of consent. According to (George 2000), female students have a negative mindset towards science and careers because mothers have influenced their daughters that science is not suitable for women. Therefore, this implies that mothers may influence their daughters' career goals. Proactive strategies to excite female students about science in the home environment early in their development could be as simple as encouraging parents to read science books to their daughters (Ford, Brickhouse et al.

2006). It has also been suggested that parents need to be coached in how to interact with their children (Gertler et al., 2014). Simply playing more with their children may help in their early development of science interests.

Conclusion

The overall framework for this study was to identify if gender influenced students' attitudes towards the subject of science, their desire to become a scientist, the importance of science to society and their stereotypical views of scientists in a NSF GK-12 program. Overall, male students, particularly in Year 5, were significantly more positive than female students about science, its value to society, and their desire to be a scientist.

Future Research

Gender bias may be a factor that influenced the results of this study. Future research in GK-12 programs should involve training teachers and resident scientists in unconscious gender biases so they are not favoring male students in their teaching practices. It is possible that gender bias training (Lavy & Sand, 2015) for teachers would improve girls' attitudes towards science and improvement could be demonstrated with pre and post MATS surveys. A variety of factors may need to be implemented both at school and at home to improve females' views of science and of science careers. Teachers should be made more aware of their personal gender biases that might impact their teaching practices. Single-sex classes in science might also improve girls' attitudes towards science and science careers (Parker & Rennie, 2010). Lastly, as astronomer Carl Sagan once stated, "As I look back, it seems clear to me that I learned the most essential things not from my school teachers, not even from my university professors, but from my parents, who knew nothing at all about science." (Sagan, 2011, p. xv). We need to encourage families and parents to teach science to their children and especially, their daughters.

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Appendix

My Attitudes Towards Science (MATS) Survey

Name of Science Teacher________Class Period_______________

	Disagree a lot	Disagree a little	Have not decided	Agree a little	Agree a lot
1. Scientists do not criticize other scientists' work.	1	2	3	4	5
2. I usually understand what we are talking about in science.	1	2	3	4	5
3. Scientists work alone.	1	2	3	4	5
4. People do not need to understand science because it does not affect their lives.	1	2	3	4	5
5. No matter how I try, I cannot understand what the teacher is describing in science class.	1	2	3	4	5
6. It makes me nervous to even think about being in a science class.	1	2	3	4	5
7. Science is easy for me.	1	2	3	4	5
8.Discoveries in science do not affect how I live.	1	2	3	4	5
9. Studying science is something that I enjoy very much.	1	2	3	4	5
10. I do not do very well in science.	1	2	3	4	5
11. I would like a job as a scientist	1	2	3	4	5
12. Our world is nicer to live in because of science.	1	2	3	4	5
13. Scientists work in labs.	1	2	3	4	5
14. You have to be old to be a scientist.	1	2	3	4	5
15. I often think, "I cannot do this," when science is being taught.	1	2	3	4	5
16. You have to be at least a little bit crazy to be a scientist.	1	2	3	4	5
17. Scientists do not try to improve upon an explanation they have discovered about the world.	1	2	3	4	5
18. Most students seem to understand science.	1	2	3	4	5
19. Science is not useful to anyone but scientists.	1	2	3	4	5
20. It scares me to have to study science.	1	2	3	4	5

	Disagree a lot	Disagree a little	Have not decided	Agree a little	Agree a lot
21. Scientists are males.	1	2	3	4	5
22. Scientists do not have enough time to have fun.	1	2	3	4	5
23. Science is one of my favorite subjects.	1	2	3	4	5
24. I have a good feeling toward science.	1	2	3	4	5
25. Only thinking is important to scientists, not how they feel about something.	1	2	3	4	5
26. Science discoveries do not help people live better.	1	2	3	4	5
27. A country could be strong even if it has no scientists.	1	2	3	4	5
28. I like science classes.	1	2	3	4	5
29. People should understand science since it is an important part of their lives.	1	2	3	4	5
30. I don't want a job as a scientist, because I have no interest in it.	1	2	3	4	5
31. I feel upset when someone talks to me about being in a science class.	1	2	3	4	5
32. The things scientists discover through their work does not affect other people in my life.	1	2	3	4	5
33. In their work, scientists report exactly what they observe.	1	2	3	4	5
34. Science helps solve the problems of everyday life.	1	2	3	4	5
35. Scientists wear lab coats.	1	2	3	4	5
36. Science is hard for most students to understand.	1	2	3	4	5
37. If one scientist says an idea is true, all other scientists will believe it.	1	2	3	4	5
38. Technology is an example of an important product of science.	1	2	3	4	5
39. A major purpose of science is to produce new drugs and save lives.	1	2	3	4	5
40. Science is helpful to understand the world.	1	2	3	4	5