education sciences

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Gender and STEM Education: An Analysis of Interest and Experience Outcomes for Black Girls within a Summer Engineering Program

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Abstract: An effective way to increase the participation of historically excluded students in engineering education is through informal programming that covers science, technology, engineering, and mathematics (STEM). This study is part of a broader investigation conducted by Fletcher aimed at evaluating the programs offered by the National Society of Black Engineers (NSBE) as part of the Summer Engineering Experience for Kids (SEEK) program at different sites. The study collected pre- and post-assessment data from 1235 girls across twelve sites to determine if there were significant differences in interest- and experience-related outcomes at single-gender and coeducation sites. The study found that the two single-gender sites out of the twelve sites had statistically significant differences in participant responses in favor of single-gender sites, with one site showing a significant association with overall enjoyment of the program. The study used social cognitive theory (SCT) and intersectionality to guide the research and found that the site type had a significant association with the results. These findings suggest the need for further exploration of the impact of site type within informal education programs, especially those targeting historically excluded populations in STEM.

Keywords: informal STEM education; broadening participation; engineering education

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Citation: Fletcher, T.; Hooper, K.; Alfonso, D.F.; Alharbi, A. Gender and STEM Education: An Analysis of Interest and Experience Outcomes for Black Girls within a Summer Engineering Program. *Educ. Sci.* **2024**, *14*, 518. https://doi.org/10.3390/educsci14050518

Academic Editors: Patricia Caratozzolo, Angeles Dominguez and Claudia Camacho-Zuñiga

Received: 7 March 2024
Revised: 28 April 2024
Accepted: 8 May 2024
Published: 11 May 2024

1. Introduction

Women, particularly Black women, in science, technology, engineering, and mathematics (STEM) fields frequently endure marginalization, despite research demonstrating that their academic performance is equal to, or even surpasses, that of their male counterparts in these fields [1,2]. Therefore, research has drawn attention to the conflict women frequently encounter between their feminine identity and their pursuit of a career in STEM, which can negatively impact their sense of belonging and persistence in the field [3–5]. Several studies have highlighted the racialized and gendered experiences of Black women in STEM and acknowledged that Black women are underrepresented in the field of engineering and tend to pursue it at lower rates than other demographic groups [6]. As a result, there is a substantial body of studies that have explored the experiences of Black women in engineering, including the factors that influence their persistence, identity development, and the unique skills they bring to the field [7,8]. Black women often experience isolation and cope by giving back to their communities [9]. Research highlights their resilience in the face of discriminatory and biased experiences.

Accordingly, broadening participation within engineering education continues to be a top priority for the nation and a target source of funding allocation for public and private organizations. However, Black and African Americans continue to be disproportionately underrepresented among students attaining an engineering degree [10]. Within this population, Black women are twice as likely to enroll in higher education compared to Black men [11]. Yet, when it comes to engineering degree attainment over the past ten years, an average of only 24% of the Black recipients were women [10,11]. A well-documented solution to increasing Black girls' interest in engineering and more broadly, in STEM, has been exposure to the curriculum and programming through pre-college and informal activities and initiatives, especially those within informal settings [12–14]. As noted earlier, research has demonstrated that informal learning programs, such as after-school, out-of-school time, and summer-based initiatives, are effective in providing Black girls with access to STEM education [15,16], which is critical given that children only spend about 18.5% of their waking hours in formal learning spaces [17,18]. These informal educational programs also provide opportunities for women in STEM careers to act as mentors or role models [14,19], which helps to broaden the participation of women in engineering and computing [20,21].

From an asset-based perspective, pre-college and informal single-gender settings contribute positively towards girls' interest in STEM at the higher education level. This is particularly true for Black and Latinx girls [22]. The next section will take an in-depth look into the literature to further explore the experiences of Black girls within STEM education, informal engineering education, and single sex versus coeducation (coed) spaces. As a note of reference, due to the limited amount of research on Black girls within formal and informal engineering education spaces, the literature is heavily focused on findings within the STEM education space.

1.1. Informal STEM Education

Informal education (after-school, before-school, summer-based, and out-of-school time programs) serves the low-income and historically excluded youth at a greater rate than the general population [23,24]. Informal programs provide services to 15% of the national school-aged population. Of this 15%, 24% are Black, 21% are Hispanic, and 16% are Native American. In total, 61% of these program participants are underrepresented minorities (URMs) [25,26]. Informal STEM programs have been found to improve students' attitudes toward STEM classes, increase interest in STEM careers, and boost academic achievement [23,27]. As encouraging as this is, many informal STEM programs struggle to provide science programming because of a lack of resources and knowledge and limited access to professional development [18,28,29].

In the Supporting Learning for Diverse Groups chapter of their report, it is stressed that the ability to learn science through informal avenues is particularly important for students from historically excluded groups [18]. The authors continue by stating that more research on the holistic learning environment most conducive for different groups is needed to understand what best supports their ability to learn. Additionally, the research community should capitalize on building on findings from informal science (i.e., STEM education) settings so that additional, innovative, and interdisciplinary approaches can be found and subsequently utilized for comparison and even longitudinal analysis [18]. Within the engineering education community, we are still in the beginning phases of conducting the research for which Bell and his colleagues have called. For example, Cardella et al. [17] found that when examining the design activities that young girls engage in as they work on engineering challenges with their parents, parents may already be guiding their daughters to an engineering education when they demonstrate the social relevance of the field.

Although research into Black girls' experiences in STEM has increased, it has primarily focused on formal settings [11,30]. To broaden their interest and participation in STEM, organizations are expanding access to and resources for informal STEM education and programming [23,31]. Informal STEM education provides opportunities for flexible curricula, activities, and more personal engagement with teachers and students that are not always possible in formal education settings [32]. Given the lack of literature on informal engineering education targeting historically excluded populations, there is a need to further explore this area. There is also a need for more research as the number of women of color entering the “T” (i.e., technology, computing, computer science) and “E” (engineering) fields of STEM is lower than the remaining STEM fields [33]. Studies are needed to determine the relationship between single-gender and coeducation settings in (in)formal education and the educational outcomes of students.

1.2. Single-Gender Versus Coeducation

From an informal learning perspective, young girls that go on to pursue careers in STEM fields are more likely to have participated in some type of informal learning activity focused on STEM or have an individual in their life who was a role model from a STEM field [34]. As previously emphasized, the dearth of scholarly research conducted within predominantly or entirely Black single-gender educational institutions, both formal and informal, represents a significant gap in the existing literature.

Bringing up Girls in Science (BUGS), an informal science-based program that was supported by the National Science Foundation (NSF), took place in Northern Texas with a group of 32 fourth and fifth grade students and provided an authentic learning experience. The participants demonstrated a significantly higher level of scientific knowledge as measured by an Iowa-based basic skills test (ITBS-S) than non-participants. Results from a longitudinal study comparing participants to non-participants’ perceptions of STEM careers showed that BUGS participants had more favorable perceptions after participating in the program, while non-participants had significantly less favorable perceptions [15,16].

An authentic learning experience was implemented to enhance the technology and science process skills in this group of fourth and fifth grade girls [15]. The curriculum, focused on mealworms, was delivered by personal mentors. The study found that participants showed high proficiency in science process skills such as formulating research questions, developing hypotheses, designing procedures, and drawing conclusions. However, improvement was needed in analysis. Additionally, participants demonstrated strong skills in presenting scientific findings using PowerPoint and Excel.

In addition, a project was conducted including female students in grades 4 and 5 from a mid-sized urban community in North Texas who were enrolled in an after-school environmental science program with a high-interest curriculum and mentor support [16]. The study examined the immediate impact of the program on the students’ science knowledge and its long-term effectiveness in shaping their perceptions of STEM careers. The findings showed that the program had a positive impact on the students’ perceptions of science careers compared to the control group. Interestingly, there were no significant differences observed between the participants, science majors, and STEM professionals in their perceptions of science and STEM careers, but the control group had a significantly lower perception than these groups.

The success of programming in the informal makerspace community can be seen in programs such as ‘I AM STEM’ and ‘Black Girls Create’. These single-gender after-school programs offer a culturally responsive curriculum that focuses on STEM capacity building, research and design, and the empowerment of Black girls. It was found that successful science and mathematics teachers play a critical role in engaging Black girls in STEM education [14]. The researchers identified the effective methods and characteristics of educators who foster passion and academic success in STEM learning for Black girls in both formal and informal settings. According to the participants, successful teachers address individual needs, create a culture of learning, and encourage critical and creative thinking. These teachers, from both ‘I AM STEM’ and the participants’ formal schools, demonstrate innovation in instruction and motivate students to reach their full potential [13].

The effectiveness of these programs is often assessed by the feedback of Black girl participants, their continued participation, and the mentor teachers’ effectiveness. For instance, a follow-up study was conducted to examine the perceptions of Black girls who participated in the “I AM STEM” program [14]. The participants found the program to be effective and enjoyable, as they were able to go on unique field trips that taught them about environmental sustainability and technological waste. The study used narrative inquiry to analyze the experiences of Black girls in both formal and informal STEM education, focusing on critical race methodology to highlight the unique experiences of girls of color. The researcher gathered qualitative data through interviews, reflection journals, student work, and memos, and used triangulation to generate six counter stories. The findings showed that the "I AM STEM" program sparked the girls' interest in STEM through hands-on activities and field trips, leading to ongoing engagement in STEM learning. Additionally, the study found that providing a platform for Black girls allowed them to express their thoughts and experiences in STEM, showcasing their enthusiasm for the subject. King and Pringle's (2018) research created a safe space for Black girls to reflect on their STEM learning, generate new perspectives, and connect their informal and formal learning environments [14].

Another study emphasized the importance of single-gender STEM environments for Black girls and the role of Black women educators in fostering safe spaces for STEM activities. The after-school program 'SISTERHOOD I AM STEM', facilitated by Black women educators, enabled a communal experience for Black girls and their families. The study highlights the significance of after-school STEM programs in boosting self-confidence and the visualization for Black girls in science [35].

The National Society of Black Engineers (NSBE) created the Summer Engineering Experience for Kids (SEEK) program in 2007 to address the underrepresentation of Black and African Americans in engineering. This program, designed for students in grades 3–5, provides hands-on educational activities centered around an engineering curriculum that incorporates math, science, and technology. The program aims to enhance students' STEM identity, broaden their horizons, and support and promote the ambitions of collegiate and pre-collegiate students, as well as technical professionals, in the fields of engineering and technology. As of 2015, SEEK had 17 program sites across 16 major U.S. cities, serving approximately 15,000 student participants and employing 2500 collegiate and professional instructors. The program is free and runs for three weeks during the summer. Since 2013, the NSBE leaders have partnered with corporate sponsors and local leaders to create all-female student and mentor-teacher program sites in Jackson, Mississippi, and Atlanta, Georgia. While there has been research conducted on the program's design methodology, conceptualization, logic model process, and overall effectiveness [6,36–38], only one study has examined differences in student experiences and interest outcomes between site types [39].

2. Conceptual Framework

This study utilizes two conceptual lenses to inform its research question, data interpretation, and program selection, namely intersectionality and Social Cognitive Theory (SCT). Intersectionality acknowledges the unique challenges faced by underrepresented female minorities who are marginalized by both gender and race, particularly in STEM education; hence, single-gender SEEK program sites were selected in our research design. Social Cognitive Theory posits that students' behaviors and actions are shaped by their experiences within social contexts. This theory offers a perspective for interpreting the experiences of female SEEK participants. The following sections will provide a more in-depth exploration of these theoretical frameworks [40].

2.1. Intersectionality

Kimberlé Crenshaw coined the term 'intersectionality' to describe how social aspects, primarily race and gender, can mold and contribute to the foundation of peoples' experiences [41]. She believes that as the interconnected nature of social categorizations, such as race, class, gender, and sexual orientation, apply to a given individual or group, they create overlapping and interdependent systems of discrimination or disadvantage. Additionally, as a critical race theory theoretical framework, intersectionality examines the construction of those social categories and explains how they are intertwined with oppression within the United States [42–46].

Intersectionality played a critical role in this study as the convergence of race and gender for female participants and could impact their experiences and interest outcomes within the target program of this study [43,47,48]. It is worth noting that research on the underrepresentation of women in STEM has highlighted the influence of intersecting identities, such as race/ethnicity and gender, in shaping their engagement in STEM activities.

Black women in STEM face unique challenges due to their race and gender, which leads to insufficient representation and support [49]. They often feel judged by their race in science classes more than their male peers and are more likely to feel excluded from their departments. These perceptions can negatively impact their experiences in STEM. Understanding the influence of intersectionality on Black girls' participation in informal STEM education is crucial. Collecting and analyzing data can help guide policy, programmatic improvements, and resource allocation within formal and informal education settings for this population. Research should also examine how gender and race categories affect different experiences [44,50–54].

2.2. Social Cognitive Theory

Bandura states that most of what we learn as humans takes place within social context through observational learning. Most of our individual attributes, such as our beliefs, attitudes towards things, and how and what we learn, are obtained through observing others, including our family members, friends, trusted members of the community, and teachers. Bandura believes that cognitive modeling takes place through the observation of other people, leading to intrinsic learning and goal-directed behavior [55,56]. This is represented in Figure 1 below, where personal, behavioral, and environmental components are seen as connecting to one another in a way that synthesizes the formulation of social cognitive theory.

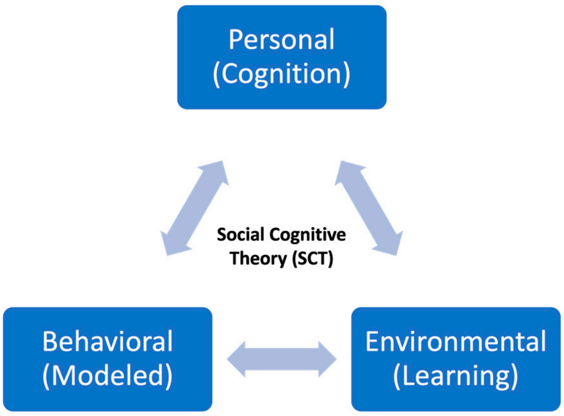

Figure 1. The Social Cognitive Theory model is used as a theoretical framework to analyze data (Bandura, 1991, 2002) [55,56].

The SEEK program is managed and executed by classroom mentors, with three mentors leading each classroom. Instructors, or "mentors", have a significant influence on the students' academic and interest outcomes in formal educational settings [57]. At single-gender sites, the mentors and students are all female, while at coed sites, the mentors and students can include both genders. In coed sites, each classroom can have either two male mentors and one female mentor or two female mentors and one male mentor. Research suggests that girls' academic and interest outcomes differ in single-gender versus coed settings regardless of race or ethnicity. Boys and girls tend to imitate and model the behavior of familiar adults, such as parents, by gender, which is similar to their experiences in the classroom with teachers [58].

While progress has been made in understanding the outcomes for Black females in various STEM settings, there is a lack of research comparing single-gender and coed informal STEM educational settings for Black girls. Few programs exist that allow for a comparative analysis, and it remains unclear how successful these programs are in increasing the number of minority girls pursuing STEM secondary and higher education and careers. Additionally, it is unclear what type of learning environment is best suited for this. Despite several programs existing, there is a gap in the literature regarding research on Black girls in single-gender informal STEM education programs. Furthermore, intersectionality should be considered when ranking factors such as race, gender, and socio-economic status. Lastly, while there is an abundance of literature suggesting that single-gender learning environments impact URMs, especially Black girls, this concept has not been grounded in theory.

This study aimed to investigate the differences in learning environments for Black girls in single-gender versus coed settings using data from NSBE SEEK by addressing the following question: *What were the results of the summer program for Black girls, in terms of self-perception, self-efficacy, and confidence in single-gender and coed settings?* Therefore, the results of the summer program were analyzed using SCT to identify the impact on self-perception, self-efficacy, and confidence. The study's findings shed light on the implications for other organizations considering single-gender programming. The research questions explored the connection between program environment and the experiences of Black girls at single-gender and coed sites. The next section discusses the methods and methodology used in the study.

3. Materials and Methods

Secondary data analysis is a method with procedural and evaluative steps that (1) begins with the development of research questions, (2) identifies dataset(s), and (3) consists of a thorough evaluation of the datasets to answer the research questions [59,60]. To address the research questions of this study, data from the pre- and post-assessments of female students were used from both single-gender and coed settings. This was achieved by following these steps:

1. Collect/obtain quantitative data from student participants.
2. Extract the male student data from the raw data gathered from the coed setting.
3. Analyze quantitative data for the female student participants, disaggregated by site type.
4. Compare both data patterns and results from both sites.
5. Interpret the findings in light of the research questions.

It is important to note that in 2015, external evaluation reports revealed that girls participating in single-gender programs demonstrated greater interest in STEM compared to those in coed sites. Despite these findings, the reports did not delve into the significance of this difference, particularly in terms of its distinction between girls at coeducational sites. Therefore, this study aimed to investigate this finding and evaluate additional interest and experience outcomes for both populations.

3.1. Target Population

Through the vision of the NSBE SEEK program, along with the findings from the literature review and data collected from organizational leadership, Table 1 highlights how our team was able to use this program for our analysis to answer the research questions. The pre- and post-program assessment results for 2 single-gender and 10 coed sites during the summer of 2015 were analyzed. Table 1 shows the full list of locations for the summer of 2015 and all the other years that the locations hosted a program during the summer. As shown, there were a total of 17 sites for the summer. However, our analysis only included 12. An explanation of this is provided within the Data Screening, Cleaning, and Coding section.

Table 1. The 17 SEEK programs by city, state, and the year that the sites had a program.

No.	City	State	No. of Years	Years
1	Atlanta *^	Georgia	3	2014, 2015, 2016
2	Birmingham *	Alabama	2	2015, 2016
3	Boston	Massachusetts	1	2015
4	Chicago *	Illinois	3	2014, 2015, 2016
5	Denver SE	Colorado	2	2015, 2016
6	Denver NE *	Colorado	4	2013, 2014, 2015, 2016
7	Detroit *	Michigan	5	2012, 2013, 2014, 2015, 2016
8	Harrisburg *	Pennsylvania	1	2015
9	Houston *	Texas	5	2012, 2013, 2014, 2015, 2016
10	Jackson *^	Mississippi	4	2013, 2014, 2015, 2016
11	Los Angeles	California	2	2015, 2016
12	New Orleans *	Louisiana	5	2012, 2013, 2014, 2015, 2016
13	Oakland *	California	5	2011, 2012, 2013, 2014, 2015
14	Philadelphia *	Pennsylvania	4	2013, 2014, 2015, 2016
15	San Diego	California	5	2011, 2012, 2013, 2014, 2015
16	Thibodaux	Louisiana	1	2015
17	Washington *	District of Columbia (D.C.)	10	2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016

Note: * denotes all sites included within the research project. ^ Denotes a single-sex (single-gender), all-girls program, including instructors. Although 2015 is the focus of this study, cities from the 2015 list that hosted SEEK sites in 2016 are also recognized.

3.2. Program Activities and Participant Selection Process

Each SEEK site was staffed by mentor teachers who participated in a week-long professional development event before the start of the program. This training included a review of the curriculum, classroom management, team building activities, and a mandatory parent/guardian orientation. Every student in each class was placed on a team to accomplish a predetermined project under the guidance of their mentors. The project could be in one of three areas, namely technical skills, artistic design, or oral presentation. The curriculum was based on the Common Core State Standards and covered basic concepts in physics, chemistry, engineering, and more. Each site had a different curriculum for each of the three weeks. During the first half of each week, the students learned about a particular prototype and applied engineering concepts. They also learned the engineering design process, math, science, and vocabulary related to the project. At the end of each week, students competed against other classes within their grade level. Parents, financial sponsors, and other stakeholders were invited to attend the competition.

Students were accepted into SEEK on a "first-come, first-serve" basis; however, returning students had priority. Sites were grouped into two categories, namely "full sites" and "half sites". Full sites accepted 100 students per grade while half sites accepted around 50 per grade. In some cases, students were added to a waitlist when their parents had to decline their original acceptance to SEEK prior to the start of the program. There were no eligibility requirements or pre-screening for students outside of the mandatory parent orientation and parental confirmation that the student would attend all 15 days of the program. Once confirmed, students were placed in classrooms containing around 20 students each and sorted by grade with three mentors assigned to each class.

3.3. Data Collection, Screening, Cleaning, and Coding

The survey utilized in the 2015 SEEK program was a comprehensive assessment tool designed to measure six educational STEM outcome constructs (a pre- and post-program assessment), each with a specific focus on either learning outcomes or student experience. The pre-assessment was administered during the first days of the first week of the program, while the post-assessment was administered during the final days of the third week, enabling a comparison of the students' progress and changes in attitudes. These constructs included their math score, science score, vocabulary score, interest in STEM, educational aspirations, and desire to become an engineer, with varying numbers of items and total points possible for each section. The completion rates for both assessments (96% for pre-assessment and 84% for post-assessment) demonstrated the participants' strong engagement. This assessment method allowed for a thorough examination of the program's impact on students' STEM knowledge and interest levels. Data criteria for sites included the following requirements:

1. At least 90% of the female roster identify as Black.
2. A sample size of at least 30 qualifying female students [61].
3. Third, fourth, and fifth graders enrolled in the program.

Out of the initial 17 sites, 5 were excluded from the analysis, namely Boston, Thibodaux, Denver SW, San Diego, and Los Angeles. While Boston focused solely on eighth-grade students, this study aimed to target third, fourth, and fifth graders. Setting a minimum of 50 female students per site, this study aimed to include as many sites as possible while also prioritizing Black girls' participation. However, Thibodaux, Denver SW, and San Diego fell short of the minimum sample size requirement. Thibodaux had 62 students, with less than 50% girls, while Denver SW had 95 students with less than 40% girls. San Diego had the closest proportion of female students at 42%, but after further review, most of their students did not identify as African American or Black, and thus did not meet the inclusion criteria. Ultimately, 12 sites met the criteria and were included in the study. Additional cleaning included removing data involving children outside of the target age range (third to fifth grade) and male student participants. Sixth grade students from the New Orleans and Houston datasets were excluded, as they were the only sites with that age group included. These changes resulted in a smaller data set for the study.

This study focused solely on the outcomes of female students; thus, male student data were eliminated. As a result, the total number of female students analyzed was 1235. Although all sites were accessible to students from diverse backgrounds, demographic data were collected for each site to determine the number of Black female participants. All sites included had a female population that was at least 90% Black based on the review. Table 2 illustrates the participation of Black girls by site.

Table 2. List of the 12 SEEK 2015 sites that met all requirements.

#	Site	No. of Girls	% Girls
1	Atlanta *	295	100.00%
2	Birmingham	53	37.41%
3	Chicago	109	45.85%
4	Denver NE	66	38.43%
5	Detroit	96	37.01%
6	Harrisburg	72	46.69%
7	Houston	115	47.83%
8	Jackson *	175	100.00%
9	New Orleans	77	37.05%
10	Oakland	69	39.15%
11	Philadelphia	56	32.06%
12	Washington, D.C.	52	33.33%
	TOTALS	1235	

Note: * denotes single-gender, all-girl site.

3.4. Data Analysis

The data analysis for this study focused on the STEM interest outcomes for Black female SEEK program participants. Raw data were pulled from the SEEK pre- and post-assessments taken by the students at the beginning and end of the 3-week program. The following statistical tests utilizing the IBM single-gender Statistics 22 statistical platform were employed to address the research questions:

1. Grouped bar charts.
2. Independent *t*-test (where at least five levels of ordinal data were available).
3. χ^2 tests.
4. Means (questions varied throughout both the pre- and post-assessment. Questions were one of the following: pre-assessment only, post-assessment only, and both pre-assessment and post-assessment).
5. Standard deviations.
Cohen's d and Effect size r (where statistically significant results are present). For the nine outcome constructs and 18 total items shown in Table 3, statistical analyses, including an independent *t*-test, a chi-squared test, and descriptive statistics organized into graphs were used to analyze and display the results.

Table 3. List of the nine outcome constructs and 18 total items analyzed for this study.

No.	Outcome Construct	Area	Items (#) *	Pre-Assessment	Post-Assessment	Total Points Possible
1	Interest in STEM	Interest Level	10	A6a-j	A1a-j	Ordinal (5 options)
2	Educational Aspirations	Interest Level	1	A2	A2	Ordinal (3 options)
3	Desire to Become an Engineer	Interest Level	1	A8	A6	Ordinal (3 options)
4	Enjoyment of SEEK	Interest Level	1	n/a	A7e	Ordinal (5 options)
5	Knowledge Transfer	Informal to Formal Learning	1	n/a	A7f	Ordinal (5 options)
6	Parental Engagement	Informal to Home Learning	1	n/a	A7g	(Ordinal (5 options)
7	Desire to Return to SEEK	Interest Level	1	n/a	A7h	Ordinal (5 options)
8	Teamwork	Program Environment	1	n/a	A7i	Ordinal (5 options)
9	Student Behavior	Program Environment	1	n/a	A7j	Ordinal (5 options)

Note: * refers to the item number in the survey.

4. Results

As noted earlier, the outcomes of interest in this study were evaluated using the SEEK program's pre- and post-program assessment tool. The results of the outcomes at both sites are presented below for both the pre- and post-program measurements.

Outcome Construct #1: Interest in STEM

The assessment of the first outcome construct, which pertains to interest in STEM, was conducted using a pre- and post-assessment question administered to all students. The question featured 10 subquestions with five ordinal options, including "No", "Not Really", "Don't Know", "Maybe", and "Yes". An independent *t*-test was conducted to determine if there was a statistically significant difference between the pre-assessment and post-assessment results by site type. Table 4 below shows the 10 subquestions A–J and highlights the negative/positive change between the pre- and post-assessments for each site type for the subquestion linked to the academic outcome construct #1: Interest in STEM, along with the results from the independent *t*-tests.

Table 4. The statistical results for the interest in STEM outcome construct.

Subquestion ID	Interest in STEM Outcome Construct	Single-Sex	Coed	*p* Value (Pre)	*p* Value (Post)
A	Science is something I get excited about.	↓	↓	0.073	0.129
B	I like math.	↓	↓	0.047 *	0.356
C	I like to take things apart to learn more about them.	↑	↓	0.839	0.943
D	I like to watch programs on TV about nature and discoveries.	↓	↓	0.136	0.074
E	I like to work on science activities.	↓	↓	0.722	0.570
F	I like reading science books.	↓	---	0.741	0.643
G	Science is useful for solving everyday problems.	↑	↑	0.333	0.909
H	I am good at science.	↓	↑	0.837	0.086
I	I am good at math.	↑	↓	0.911	0.020 *
J	I like to build things.			0.000 ***	0.536

Notes: * $p < 0.05$, *** $p < 0.001$. ↑↓ refer to the increase and decrease that happened after the program.

Table 4 shows three instances between the pre- and post-assessment results in which there was a statistically significant difference between results for single-gender and coed responses including the following: subquestion B, "*I like math*", for the pre-assessment, subquestion I, "*I am good at math*", on the post-assessment, and subquestion J, "*I like to build things*", for the pre-assessment. For subquestion B, single-gender participants had a higher mean average (4.06) than coed participants (3.92), and the difference was statistically significant ($p = 0.047$). For pre-assessment subquestion J, coed participants had a higher mean average (4.56) than single-gender participants (4.37) and the difference were also statistically significant ($p < 0.0001$).

Subquestion I was the only post-assessment question that showed a statistically significant difference. Results showed that single-gender participants had a higher mean average (4.27; SD = 1.190) than the coed participants (4.15; SD = 1.292), being statistically significant by $p = 0.020$. The Cohen's d and Effect size r were calculated for this question. The results are as follows:

Cohen's d (DV = SubQuestionI; IV = single-gendervscoed): 0.097

Effect size r (DV = VocabDiff; IV = single-gendervscoed): 0.048

According to the information provided, the general impact of these findings is rather limited. Nonetheless, Table 5 presents a comprehensive summary of the outcomes from all nine pertinent constructs.

Table 5. Summary of comparative results of single-gender and coed settings.

Assessment #	Outcome Construct	Results (Single-Gender vs. Coed Site)	*p* Value	χ^2
Post A7e	Enjoyment of SEEK	single-gender > coed	0.000 ***.	0.004 **
Post A7f	Knowledge Transfer	single-gender > coed	0.013 *	0.064
Post A7g	Parental Engagement	single-gender > coed	0.008 **	0.500
Post A7h	Desire to Return to SEEK	single-gender > coed	0.273	0.153
Post A7i	Teamwork Challenges	single-gender < coed	0.036 *	0.056
Post A7j	Student Behavior	single-gender > coed	0.008 **	0.465

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Because there were not at least five levels of ordinal data included, an independent *t*-test was not conducted for outcomes 2 and 3. Table 5 reflects a higher number of means were in favor of the single-gender sites compared to coed sites. Three of these means were statistically significant, although the chi-squared results showed that there was no statistically significant association between the question and the site type. Further details regarding the specific aspects of the outcome constructs are provided below.

Outcome Construct #1: Interest in STEM

The assessment of the first outcome construct, which pertains to interest in STEM, was conducted using a pre- and post-assessment question administered to all students. The question featured 10 subquestions with five ordinal options, including "No", "Not Really", "Don't Know", "Maybe", and "Yes". An independent *t*-test was conducted to determine if there was a statistically significant difference between the pre-assessment and post-assessment results by site type. Table 5 above shows the 10 subquestions A–J and highlights the negative/positive change between the pre- and post-assessments for each site type for the subquestion linked to the academic outcome construct #1: Interest in STEM, along with the results from the independent *t*-tests.

Outcome Construct #2: Educational Aspirations

When asked how far they want to go in school, interestingly, there was an increase in the number of female students that selected the highest option, "Beyond College", at both site types. However, the coed sites had a greater increase, 2.87% versus 0.43% at the single-gender sites (Figure 2).

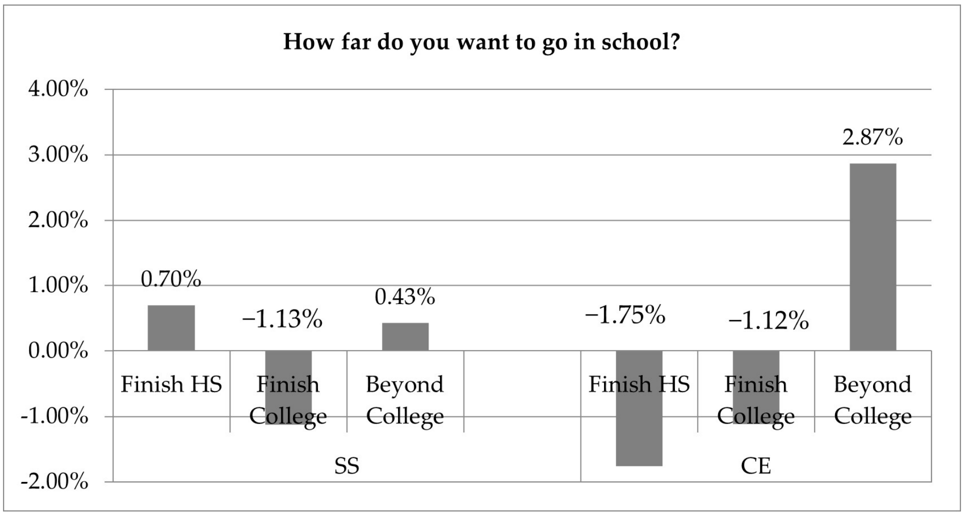

Figure 2. Pre- and post-assessment responses for "How far do you want to go in school?" (pre-post A2).

Because there were not at least five levels of ordinal data included, an independent *t*-test was not conducted. Results from the chi-squared test showed that there was not a statistically significant association between the question asked and the site type for the pre-assessment ($p = 0.225$) or the post-assessment ($p = 0.824$).

Outcome Construct #3: Desire to Become an Engineer

When asked if they would ever consider becoming an engineer, there was an increase in the number of female students that selected "Yes" at single-gender sites (9.79%), but a decrease at coed sites (−11.31%). Additionally, the coed sites had an increase in the number of females that selected "No" (2.42%) versus the single-gender sites, which also saw a decrease in the number females that selected "No" (−2.55%). The coed sites showed an increase in the number of "Maybe" selections (8.88%) while the single-gender site saw a decrease (−7.23%) (Figure 3).

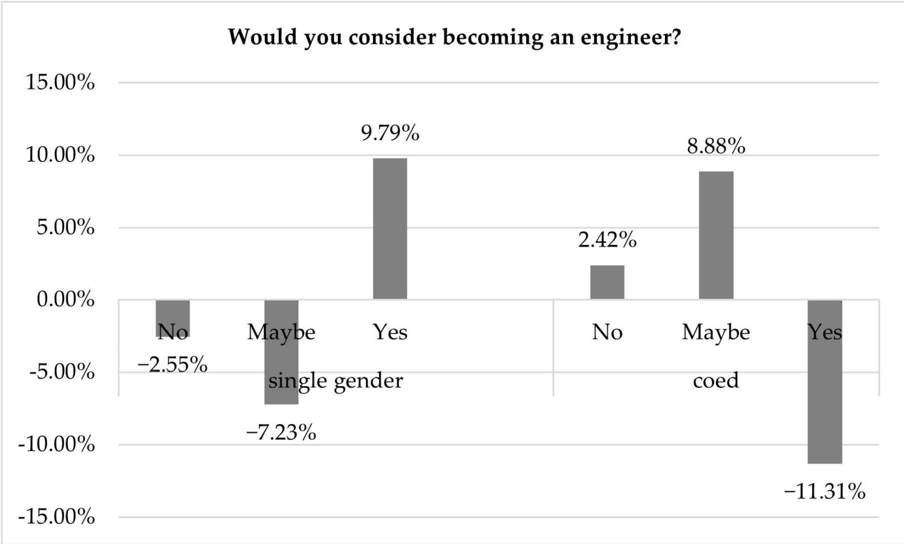

Figure 3. Pre- and post-assessment responses for "Would you consider becoming an engineer?".

Due to the lack of a minimum of five levels of ordinal data, an independent *t*-test was not conducted. Results from the chi-squared test showed that there was a statistically significant association between the question asked and the site type for the pre-assessment ($p = 0.044$), but not on the post-assessment ($p = 0.632$). Considering the distinct differences in responses to this question between the two site types, Cohen's d and Effect size r were calculated. The results were:

Cohen's d Effect size (DV = FutureEng; IV = single-gendervscoed): 0.0147

Effect size r (DV = FutureEng; IV = single-gendervscoed): 0.0073

Based on this information, the overall effect of these results is small.

Outcome Construct #4: Enjoyment of SEEK

When asked if they had fun this summer in the program, the single-gender sites had a greater percentage of participants who selected "Yes" or "Maybe" (86.5%) versus the female participants at the coed sites (79.1%). Additionally, there were almost twice as many female participants at coed sites who selected "No" or "Not Really" (14.4%) in contrast to the females at the single-gender sites (8.10%) (Figure 4).

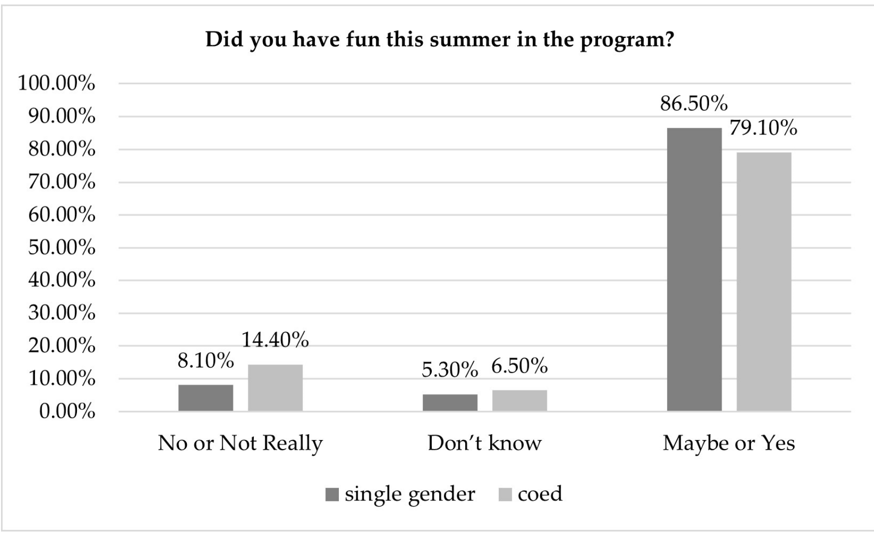

Figure 4. Post-assessment responses for "Did you have fun this summer in the program?" (post-A7e).

A chi-squared test was conducted, revealing the asymptotic significance level (2-sided) of 0.004, which means that we fail to reject the null as there is a statistically significant association between the type of site and response to question PostA7e, "Did you have fun this summer in the program?" Additionally, an independent *t*-test was conducted to determine if there was a significant difference between the responses for each group on the post-assessment as this question was only asked on the post-assessment. Results showed that single-gender participants had a higher mean average (3.52) than coed participants (3.27) and the difference was statistically significant ($p < 0.0001$). The Cohen's d and Effect size r were calculated because there were statistically significant differences in responses between the two site types. The results were:

Cohen's d Effect size (DV = EnjoySEEK; IV = single-gendervscoed): 0.2187

Effect size r (DV = EnjoySEEK; IV = single-gendervscoed): 0.1087

Based on this information, the overall effect of these results is moderate.

Outcome Construct #5: Knowledge Transfer

When asked if they learn something this summer that will help you in school, the single-gender sites had a higher percentage of participants that selected "Yes" or "Maybe" (85.3%) versus the female participants at the coed sites (81.7%). Additionally, there was a greater percentage of coed female participants who selected "No" or "Not Really" (9.4%), which varied from females at single-gender sites (7.7%) (Figure 5).

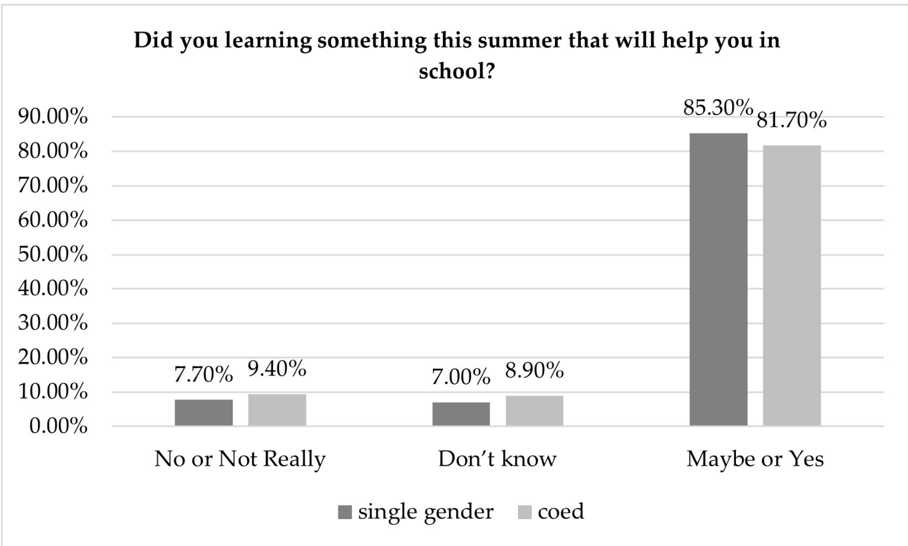

Figure 5. Post-assessment responses for "Did you learn something this summer that will help you in school?".

A chi-squared test revealed that the asymptotic significance level (2-sided) was 0.064, indicating that there was no statistically significant association between the type of site and response to question PostA7f, "Did you learn something this summer that will help you in school?" The independent *t*-test revealed a statistically significant difference between the groups' mean averages on the post-assessment question "Did you learn something this summer that will help you in school?" with single-gender participants having a higher mean average (3.47) than coed participants (3.33) ($p = 0.013$).

Outcome Construct #6: Parental Engagement

When asked if they talked to their parents about what they learned in the program, the single-gender sites had a higher percentage of participants that selected "Yes" or "Maybe" (78.7%) versus the female participants at the coed sites (74.1%). Additionally, there was a greater percentage of coed female participants who selected "No" or "Not Really" (21%) than single-gender site participants (17.5%) (Figure 6).

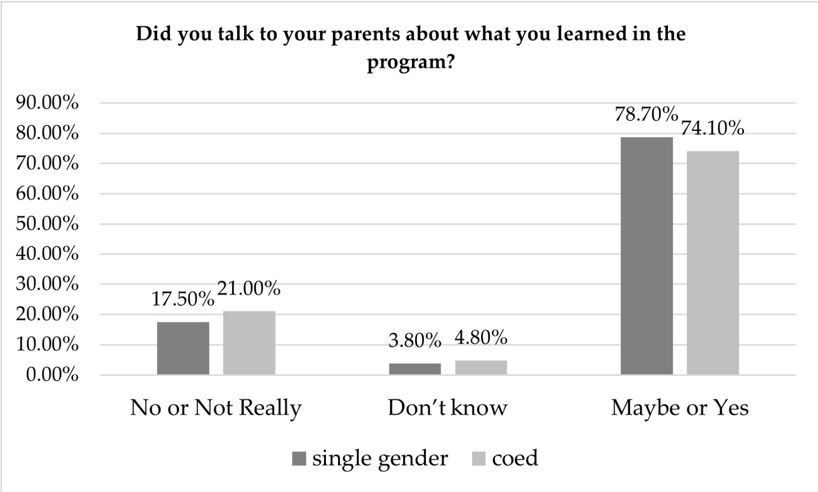

Figure 6. Post-assessment responses for "Did you talk to your parents about what you learned in the program?" (postA7g).

A chi-squared test was conducted, and the asymptotic significance level (2-sided) was 0.500, which means there was no statistically significant association between the type of site and the response to question PostA7g, "Did you talk to your parents about what you learned in the program?" The independent *t*-test showed that single-gender participants had a higher mean average (3.21) than coed participants (3.07) and the difference was statistically significant ($p = 0.008$) on the post-assessment.

Outcome Construct #7: Desire to Return

When asked if they would like to come to the SEEK program next summer, the single-gender and coed sites had about an even number of female participants who selected "Yes" or "Maybe" (71.7% and 69.4%). However, coed sites had a greater percentage of female participants who selected "No" or "Not Really" (19.2%) versus the females at the single-gender sites (16%) (Figure 7).

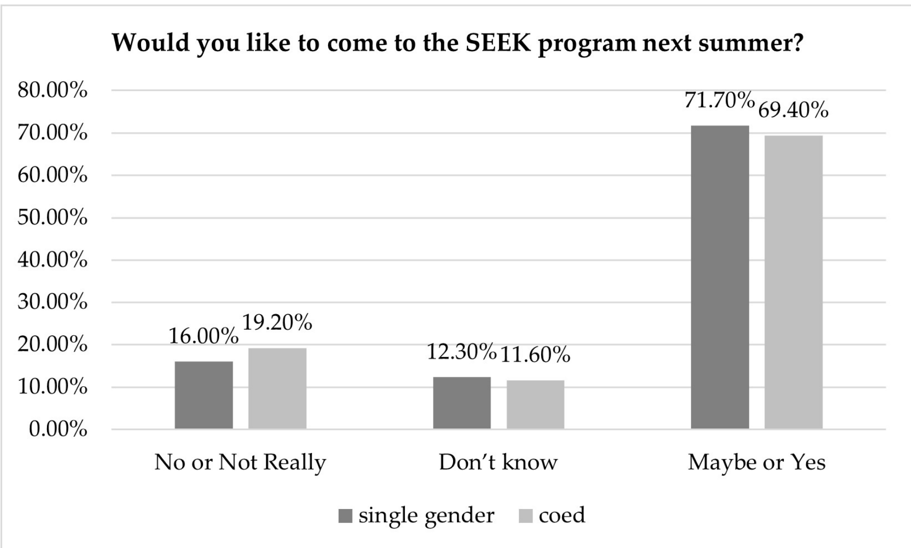

Figure 7. Post-assessment responses for "Would you like to come to the SEEK program next summer?" (post-A7h).

A chi-squared test showed that the asymptotic significance level (2-sided) was 0.153, indicating that there was no statistically significant association between the type of site and response to question PostA7h, "Would you like to come to the SEEK program next summer?" Additionally, an independent *t*-test showed that single-gender participants had a higher mean average (2.98) than coed participants (2.87); however, the results were not statistically significant ($p = 0.273$).

Outcome Construct #8: Teamwork

When asked if they had any problems working on their teams, the coed sites had a slightly greater percentage of participants that selected "Yes" or "Maybe" (50.4%) versus the female participants at the single-gender sites (48.5%). Additionally, there was a greater percentage of single-gender female participants who selected "No" or "Not Really" (46.2%) compared to the females at the coed sites (42.9%) (Figure 8).

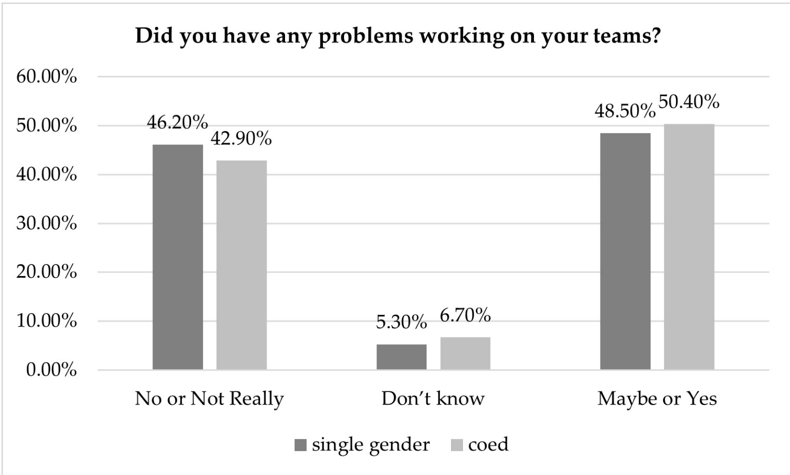

Figure 8. Post-assessment responses for "Did you have any problems working on your teams?" (post-A7i).

A chi-squared test demonstrated that the asymptotic significance level (2-sided) was 0.056, proving that there was no statistically significant association between the type of site and response to question PostA7i "Did you have any problems working on your teams?" An independent *t*-test showed that single-gender site participants had a higher mean average (2.06) than the coed site participants (2.20), which is a statistically significant difference ($p = 0.036$).

Outcome Construct #9: Student Behavior

When asked, "Were there any times you were teased or picked on or left out of activities?" the single-gender sites had a greater percentage of participants that chose "Yes" or "Maybe" (34.1%) versus the female participants at the coed sites (29.8%). Furthermore, a smaller percentage of single-gender female participants selected "No" or "Not Really" (61.2%) compared to the females at the coed sites (64.2%) (Figure 9).

A chi-squared test was conducted, and the asymptotic significance level (2-sided) was 0.465, which indicated that there was no statistically significant association between the type of site and response to question PostA7j, "Were there any times you were teased or picked on or left out of activities?" The independent *t*-test revealed that single-gender site participants had a higher mean average (1.41) than coed participants (1.29), a statistically significant difference ($p = 0.008$).

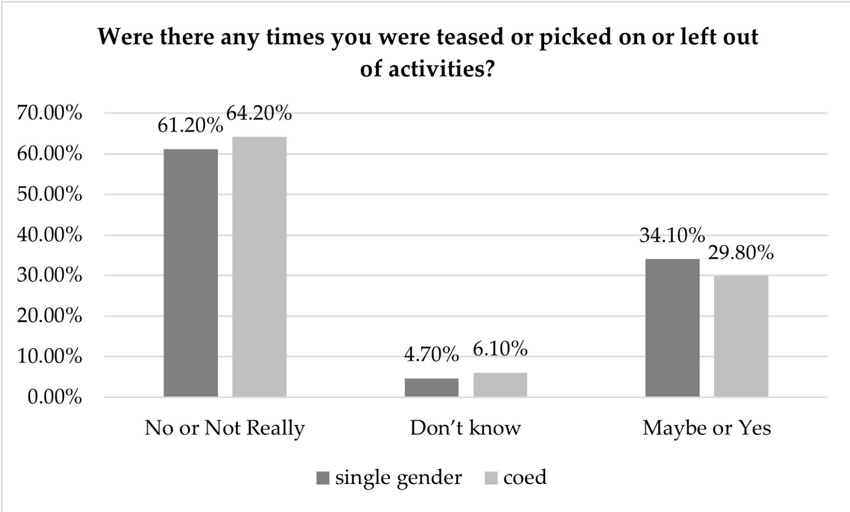

Figure 9. Post-assessment responses for "Were there any times you were teased or picked on or left out of activities?" (post-A7j).

5. Discussion

The objective of this study was to uncover the influence of educational settings, namely single-gender and coed settings, on the STEM interest of female students. The results of this study highlighted that the educational setting plays a discernible role in influencing the STEM interests of female students. This is demonstrated by the improvement in four out of ten subquestions for participants in the single-gender sites that may imply that such environments are more effective in fostering certain aspects of STEM interest. However, we cannot overlook the decrease in six subquestions that also highlights potential areas where single-gender settings may not be as advantageous. Conversely, the increase in only two subquestions and decrease in eight for coed site may suggest that coed settings are not as conducive to fostering STEM interest among female students. Taking into consideration the substantial outcomes that emphasize the influence of the educational environment on STEM interest, there were the following three significant differences between the two groups in pre- and post-assessment results: subquestion B, "*I like math*", pre-assessment; subquestion I, "*I am good at math*", post-assessment; and subquestion J, "*I like to build things*", pre-assessment.

In more detail, the study found that the participants who attended the single-gender sites for subquestions B and I had higher mean averages compared to those who attended the coed sites. However, for subquestion J, coed female participants had a higher mean average. The results suggest that single-gender site participants had a more empowering experience that allowed them to develop interests in math and feel confident in their abilities, whereas coed female participants did not experience the same level of empowerment. This self-perception may be the root cause for the reason why these female participants developed an affinity for mathematics. The prevalence of male dominance in STEM fields highlights the significance of providing female participants with the chance to view themselves as proficient in mathematics without the added pressure of competing with boys in a coed environment. Regarding subquestion J, it is recommended to explore teachers' perception, pedagogical approaches and materials, and other relevant factors that may influence female students' future STEM accomplishments.

The data indicate that in single-gender settings, female participants showed a greater interest in pursuing engineering careers compared to their counterparts in coed settings. This may be due to the increased self-assurance experienced by students in single-gender settings, as evidenced by a decrease in those who responded with "Don't know". It is reasonable to suggest that the absence of male dominance in the single-gender setting enhanced these female participants' self-esteem and confidence, reduced gender stereotypes, and enabled them to view themselves as capable of studying STEM, excelling, and pursuing careers in the field. This finding is consistent with the results of a previous study that showed that female participants involved in BUGS had a significantly higher level of confidence in science [16].

Only one of the outcome constructs had a chi-squared significance level greater than the threshold of 0.05, which was #4, Enjoyment of SEEK ($\chi^2 = 0.004$). This question also demonstrated statistical significance between the two groups ($p < 0.0001$). This indicates a strong association between the responses and the site type, suggesting that female participants at single-gender sites had a more positive experience of SEEK than those at coed sites. To create an environment that fosters the enjoyment of STEM for female participants, it is essential to eliminate gender-related issues and challenges. In the single-gender setting, the female participants demonstrated effective collaboration and established functional networks without encountering any impediments. Moreover, single-gender settings may foster confidence and self-esteem in female participants and reduce unnecessary social obstacles that can hinder progress and divert energy and focus away from achievement and excellence. An equitable and engaging environment that eliminates gender barriers is necessary for female participants to thrive, develop a keen interest in STEM, and feel empowered to pursue STEM careers.

The results of five of the six constructs showed that single-gender sites mean scores (post-assessment questions only) were higher than those at coed sites, and four of those five were statistically significant. These findings suggest that single-gender settings offer a more positive experience for female students in summer engineering programs and in sharing their knowledge with their parents or guardians than coed settings.

Family dynamics may also play a role in parent engagement, but the fact that a greater percentage of participants in single-gender settings reported engaging with family members suggests that they may have felt more empowered and confident in sharing their experiences in STEM. This also indicates a high level of interest and enthusiasm for STEM topics among the participants. Furthermore, the decrease in "Don't know" responses among female participants in single-gender settings is noteworthy, as it suggests a psychological influence, possibly reflecting a greater sense of confidence and assurance compared to those in coed settings.

It has been shown that single-gender STEM environments can provide positive social experiences for Black girls, which is crucial for promoting their innovations in the field and fostering collaboration [35]. King and Pringle (2018) also highlighted the importance of offering credence and counterspace to Black girls to showcase their exceptional aptitude in STEM education [14]. A single-gender environment can provide a counterspace where competition is minimal, and gender stereotypes are not present, making it easier for female participants to exhibit less hesitancy, greater determination, and a positive attitude. This study's results support this notion, demonstrating the shift from the margin to the center is more accessible in such an environment which can offer a counterspace, where competition is minimal, and the obstacle of gender stereotypes is not present. Consequently, the students exhibited less hesitancy, greater determination, and a positive attitude.

Additionally, female perceptions of student behavioral management by classroom instructors are more likely to be positively perceived in single-gender settings than in coed settings. This is important for individuals within this study who fall into a more intersectional bucket. Intersectionality from a non-power perspective and simply a 'matter of fact' angle should be included in research conversations. By not doing so, research results could lead to inaccurate or negative policy implications or misguided funding allocation.

There are several factors that play or could play a role in the results we have seen in previous sections. These factors include race, gender, program site type, mentors' backgrounds, SES, site location, mentors' years of experience, and students' pre-program exposure to STEM. Research demonstrated that these factors could influence student outcomes, including academic and interest outcomes, within any program [42,45,47].

So, single-sex or coeducation?

Results from the quantitative analysis showed outcomes of both site types. For single-gender, all-girl sites, there were four findings that showed statistically significant differences between site types, and they were all in favor of single-gender sites:

1. Girls at single-gender sites had significantly higher desires to become engineers after the program.
2. Females at single-gender sites had significantly higher responses when asked if they enjoyed the program.
3. Significantly higher, more positive results occurred when asked, "I am good at math" (From 0.911 on pre-assessment to 0.020 on the post-assessment).
4. Significantly higher responses on if they would use knowledge during SEEK outside of the program.
5. Significantly higher responses on sharing what they had learned with their parents.

For coed sites, there was one statistically significant difference between site types that favored coed sites:

1. Girls at coed sites were less likely to say they have been teased or picked on.

This bullying environment reported in the single-gender setting is worth further investigation to uncover the underlying causes that contributed to such behavior.

This study revealed nine key findings that favored single-gender sites over coed sites, with only two findings in favor of coed sites. In a single-gender environment, the role of gender is crucial and cannot be overlooked. In such settings where male dominance is not an issue, female participants' typical barriers against engaging and progressing are eliminated, enabling them to establish supportive peer networks that nurture STEM identities. Thus, single-gender sites may offer a more positive, engaging, and inclusive environment for female participants than coed sites. To determine if these findings hold true over multiple years, a longitudinal analysis is recommended. If consistent results are found, providers of STEM OST programs nationwide, particularly those serving Black girls, can be recommended to increase the number of single-gender programs for female students. However, this change would need to address the advantages of coed sites, such as teamwork, which was found to be lower in single-gender sites. To counteract potential negative impacts of teachers' internal gender stereotypes, instructional materials should be designed to prevent single-gender settings from becoming environments where female gender stereotypes flourish and deter female participants from pursuing STEM fields. This is crucial for sustaining the interest of female participants in STEM.

The primary aim of the SEEK program is to foster positive long-lasting changes related to STEM interests; therefore, it might be necessary to customize its approach according to the educational setting to optimize positive results in STEM interest and self-perception among female students. The findings of this study could also be utilized by educators and policymakers when making decisions about the structure of educational programs and initiatives that aspire to increase female participation in STEM fields.

This study offered valuable insights into the outcomes of the summer engineering program for Black girls in terms of their self-perception, self-efficacy, and confidence at single-gender and coed sites, as well as the potential implications for their interest and involvement in the field. However, the limitations of this study as a quantitative inquiry are acknowledged. Therefore, a subsequent qualitative study is recommended to explore the subquestions that have undergone changes after the program and were not addressed, to provide a more comprehensive understanding of both sites. Additional research is also necessary to scrutinize specific elements of single-gender and coed educational environments that contribute to the highlighted differences. Such studies will offer a better understanding that facilitates the development of more effective learning contexts that encourage female students' interest in STEM.

6. Conclusions

The lack of diversity in STEM fields, particularly among underrepresented minorities (URMs), is a major concern in the United States. To address this issue, it is crucial to increase URMs' access to high-quality STEM education. Outside of formal education, URMs are more likely to participate in informal STEM and non-STEM programs. Therefore, it is important to leverage this time to educate URMs about STEM education and careers, especially for African American and Black women and girls. Although Black women are attending and graduating from college at higher rates than Black men, these rates reverse when controlling for STEM and engineering degrees. As noted earlier, this highlights the need for further research on the potential benefits of single-gender educational environments in fostering an inclusive and empowering atmosphere that encourages girls to pursue STEM fields. However, this study also revealed various factors that could have influenced female students' responses to the pre- and post-assessment questions, as well as differences in their responses between the two assessments.

This provides an opportunity to research informal STEM education for Black women and girls and look at their experiences in single-gender versus coed environments within the same program. Particularly, populations including researchers, policy makers, NSBE, and other organizations who strive to increase the quality of informal STEM education and broaden participation within STEM, will benefit from the findings. When determining the most effective informal learning environment and program structure for educating Black girls in STEM, there are multiple areas that need to be considered including the most suitable learning environments and implications of intersectionality. It is important for researchers and practitioners to recognize these areas to increase the interest level of Black girls and women within STEM fields.

Author Contributions: Conceptualization, T.F., methodology, T.F., K.H., D.F.A. and A.A.; data collection and analysis, T.F., validation, T.F., K.H., D.F.A. and A.A.; resources, K.H., D.F.A. and A.A.; writing—original draft preparation, T.F.; writing—review and editing, K.H., D.F.A. and A.A.; visualization, T.F.; funding acquisition, T.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Science Foundation grant number 2143173.

Institutional Review Board Statement: This study was conducted in accordance with the National Society of Black Engineers (NSBE) approved by the Institutional Review Board at Florida International University (protocol code IRB-22-0055; approved 22 February 2022).

Informed Consent Statement: Informed consent was obtained from the National Society of Black Engineers (NSBE) to use the secondary data within this study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to an external organization owning the original, raw data.

Acknowledgments: We would like to thank the leadership at the National Society of Black Engineers (NSBE) for their ongoing support and collaboration on this research.

Conflicts of Interest: The authors declare no conflicts of interest. Additionally, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Beasley, M.A.; Fischer, M.J. Why they leave: The impact of stereotype threat on the attrition of women and minorities from science, math and engineering majors. *Soc. Psychol. Educ.* **2012**, *15*, 427–448. [CrossRef]
2. Eccles, J.S.; Jacobs, J.E.; Harold, R.D. Gender-role stereotypes, expectancy effects, and parents' role in the socialization of gender differences in self-perceptions, and skill acquisition. *J. Soc.* **1990**, *46*, 183–201.
3. Godwin, A.; Potvin, G. Fostering female belongingness in engineering through the lens of critical engineering agency. *Int. J. Eng. Educ.* **2015**, *31*, 938–952.

4. Good, C.; Rattan, A.; Dweck, C.S. Why do women opt out? Sense of belonging and women's representation in mathematics. *J. Pers. Soc. Psychol.* **2012**, *102*, 700–717. [CrossRef] [PubMed]
5. Seymour, E.; Hewitt, N. *Talking about Leaving: Why Undergraduates Leave the Sciences*; Westview Press: Boulder, CO, USA, 1997.
6. Fletcher, T.L.; Ross, M.; Tolbert, D.; Holly, J.; Cardella, M.; Godwin, A.; DeBoe, J. *Ignored Potential: A Collaborative Road Map for Increasing African-American Women in Engineering*; The National Society of Black Engineers: Washington, DC, USA, 2017.
7. Lord, S.M.; Camacho, M.M.; Layton, R.A.; Long, R.A.; Ohland, M.W.; Wasburn, M.H. Who's persisting in engineering? A comparative analysis of female and male Asian, Black, Hispanic, Native American, and White students. *J. Women Minor. Sci. Eng.* **2009**, *15*, 167–190. [CrossRef]
8. McGee, E.O.; Bentley, L. The troubled success of Black women in STEM. *Cogn. Instr.* **2017**, *35*, 265–289. [CrossRef]
9. Ong, M.; Jaumot-Pascual, N.; Ko, L.T. Research literature on women of color in undergraduate engineering education: A systematic thematic synthesis. *J. Eng. Educ.* **2020**, *109*, 581–615. [CrossRef]
10. American Society of Engineering Education. Engineering by the Numbers: 2017–2018. 2018. Available online: https://ira.asee.org/by-the-numbers (accessed on 2 February 2024).
11. Fletcher, T.L.; Jefferson, J.P.; Boyd, B.; Park, S.E.; Crumpton-Young, L. Impact of COVID-19 on sense of belonging: Experiences of engineering students, faculty, and staff at Historically Black Colleges and Universities (HBCUs). *J. Eng. Educ.* **2023**, *112*, 488–520. [CrossRef]
12. Fletcher, T.L.; Ross, M.S.; Carr, C.A.; Boyd, B. Classroom instructors' perceptions of site leadership and interest outcomes within a summer engineering program (evaluation). In Proceedings of the 2017 American Society for Engineering Education Annual Conference & Exposition, ASEE Conferences, Colombus, OH, USA, 25–28 June 2017. [CrossRef]
13. King, K.J. When teachers get it right, voices of black girls' informal STEM learning experiences. *J. Multicult. Aff.* **2017**, *2*, 5.
14. King, K.J.; Pringle, R.M. Black girls speak STEM: Counterstories of informal and formal learning experiences. *J. Res. Sci. Teach.* **2018**, *56*, 539–569. [CrossRef]
15. Harrell, P.E.; Walker, M.; Hildreth, M.T.; Tyler-Wood, T. Mentoring BUGS: An integrated science and technology curriculum. *J. Comput. Math. Sci. Teach.* **2004**, *23*, 367–378.
16. Tyler-Wood, T.; Ellison, A.; Lim, O.; Periathiruvadi, S. Bringing up girls in science (BUGS): The effectiveness of an afterschool environmental science program for increasing female students' interest in science careers. *J. Sci. Educ. Technol.* **2012**, *21*, 46–55. [CrossRef]
17. Cardella, M.E.; Svarovsky, G.N.; Dorie, B.L. Gender research on adult-child discussions within informal engineering environments (GRADIENT): Early findings. In Proceedings of the ASEE Annual Conference & Exposition, Atlanta, GA, USA, 23–26 June 2013. [CrossRef]
18. Bell, P.; Lewenstein, B.; Shouse, A.; Feder, M. Learning science in informal environments: People, places, and pursuits. *Mus. Soc. Issues* **2009**, *4*, 113–124. [CrossRef]
19. Demetriou, C.; Schmitz-Sciborski, A. Integration, motivation, strengths, and optimism: Retention theories past, present and future. In *Proceedings of the 7th National Symposium on Student Retention*; The University of Oklahoma: Charleston, SC, USA, 2011; pp. 300–312.
20. STEM Education Coalition. The Case of Investing in Out-of-School Learning as a Core Strategy in Improving Science, Technology, Engineering and Mathematics (STEM) Education. 2016. Available online: https://www.stemedcoalition.org/updates/essa-9xrkz-mctmt-7fx8k-k2cbl-z4x5m-37rdx-rzxzf-2ef9x-t2few-xttx6-r2w77-c7pwy (accessed on 7 May 2024).
21. Dierking, L.D.; Falk, J.H. Family behavior and learning in informal science settings: A review of the research. *Sci. Educ.* **1994**, *78*, 57–72. [CrossRef]
22. Rosenthal, L.; London, B.; Levy, S.R.; Lobel, M. The roles of perceived identity compatibility and social support for women in a single-sex STEM program at a co-educational university. *Sex Roles A J. Res.* **2011**, *65*, 725–736. [CrossRef]
23. Boys and Girls Club of America. Boys & Girls Clubs of America Great Think STEM: Advancing Underrepresented Youth in STEM during Out-of-School Time. 2014. Available online: https://issuu.com/bgca/docs/stem-great-think-white-paper-final-/5 (accessed on 7 March 2024).
24. Gonzalez, H.B.; Kuenzi, J.J. *Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer*; CRS Report No. R42530; Library of Congress Congressional Research Service: Washington, DC, USA, 2012; Available online: http://www.fas.org/sgp/crs/misc/R42642.pdf (accessed on 11 February 2024).
25. Afterschool Alliance. Afterschool: A Vital Partner in STEM Education. 2011. Available online: http://www.afterschoolalliance.org/Afterschool_as_STEMpartner.pdf (accessed on 10 December 2023).
26. Durlak, J.A.; Weissberg, R.P.; Pachan, M. A meta-analysis of after-school programs that seek to promote personal and social skills in children and adolescents. *Am. J. Psychol.* **2010**, *45*, 294–309. [CrossRef] [PubMed]
27. Henley, J.O.; Mccarthy, P. Advancing Underrepresented Youth in STEM during Out-of-School Time [White Paper]. 2014. Available online: https://drdamonawilliams.com/wp-content/uploads/BGCA_DAW_STEM-GT-White-Paper.pdf (accessed on 10 January 2024).
28. National Research Council. *Identifying and Supporting Productive STEM Programs in Out-of-School Settings*; National Academies Press: Cambridge, MA, USA, 2015.
29. Peter, N.; Promising Practices in Out-of-School Time Professional Development. Departmental Papers (SPP). 2007. Available online: https://repository.upenn.edu/handle/20.500.14332/47400 (accessed on 15 January 2024).

30. Espinosa, L.L. Pipelines and pathways: Women of color in undergraduate stem majors and the college experiences that contribute to persistence. *Harv. Educ. Rev.* **2011**, *81*, 209–240. [CrossRef]
31. Jayaratne, T.E.; Thomas, N.G.; Trautmann, M. Intervention program to keep girls in the science pipeline: Outcome differences by ethnic status. *J. Res. Sci. Teach.* **2003**, *40*, 393–414. [CrossRef]
32. Melnic, A.S.; Botez, N. Formal, non-formal and informal interdependence in education. *Econ. Transdiscipl. Cogn.* **2014**, *17*, 113–118.
33. Hill, C.; Corbett, C.; St. Rose, A. *Why So Few? Women in Science, Technology, Engineering and Mathematics*; AAUW: Washington, DC, USA, 2010. Available online: https://files.eric.ed.gov/fulltext/ED509653.pdf (accessed on 12 December 2023).
34. Baker, D.; Leary, R. Letting girls speak out about science. *J. Res. Sci. Teach.* **1995**, *32*, 3–27. [CrossRef]
35. Edwards, E.B.; King, N.S. Girls hold all the power in the world: Cultivating sisterhood and a counterspace to support STEM learning with black girls. *Educ. Sci.* **2023**, *13*, 698. [CrossRef]
36. Edwards, C.D.; Lee, W.C.; Knight, D.B.; Reid, K.W.; Fletcher, T.L.; Meeropol, G. Maximizing accessibility: Providing summer engineering experiences for racially, ethnically, and economically underrepresented youth. In Proceedings of the Collaborative Network for Engineering and Computing Diversity (CoNECD), Crystal City, VA, USA, 8–11 February 2018.
37. Lee, W.C.; Knight, D.B.; Cardella, M.E. Promoting equity by scaling up summer engineering experiences: A retrospective reflection on tensions and tradeoffs. *J. Pre-Coll. Eng. Educ. Res.* **2021**, *11*, 138–154. [CrossRef]
38. Young, G.D.; Knight, D.B.; Lee, W.; Cardella, M.; Hynes, M.; Reid, K.; Fletcher, T.L. Leveraging a multi-partner approach to develop successful STEM outreach programs. In Proceedings of the 2017 IEEE Frontiers in Education Conference (FIE), Indianapolis, IN, USA, 18–21 October 2017. [CrossRef]
39. Fletcher, T.L. Outcomes for Female Students within a Summer Engineering Program: Single-Sex versus Coeducation. Ph.D. Thesis, Purdue University, West Lafayette, IN, USA, 2017.
40. Bandura, A. Social cognitive theory of human development. In *International Encyclopedia of Education*, 2nd ed.; Husen, T., Postlethwaite, T.N., Eds.; Elsevier: Amsterdam, The Netherlands, 1996; pp. 5513–5518.
41. Crenshaw, K. Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *Univ. Chic. Leg. Forum* **1989**, *8*, 271–282. [CrossRef]
42. Carastathis, A. *Intersectionality, Origins, Contestations, Horizons*; University of Nebraska Press: Lincoln, NE, USA, 2016.
43. Charleston, L.J.; Adserias, R.P.; Lang, N.M.; Jackson, J.F.L. Intersectionality and STEM: The role of race and gender in the academic pursuits of african american women in STEM. *J. Progress. Policy Pract.* **2014**, *2*, 273–293.
44. Clutterbuck, D. Making the most of informal mentoring: A positive climate is key. *Dev. Learn. Organ. Int. J.* **2004**, *18*, 16–17. [CrossRef]
45. Collins, P.H. *Black Feminist thought: Knowledge, Consciousness, and Empowerment*, 1st ed.; Routledge: Abingdon, UK, 2000.
46. TEDWomen. The Urgency of Intersectionality. 2016. Available online: https://www.ted.com/talks/kimberle_crenshaw_the_urgency_of_intersectionality?language=en (accessed on 21 January 2023).
47. Carbado, D.W. Colorblind intersectionality. *J. Women Cult. Soc.* **2013**, *38*, 811–845. [CrossRef]
48. Decuir-Gunby, J.T.; Grant, C.; Gregory, B.B. Exploring career trajectories for women of color in engineering: The experiences of African American and Latina engineering professors. *J. Women Minor. Sci. Eng.* **2013**, *19*, 209–225. [CrossRef]
49. Sanchez, M.E.; Hypolite, L.I.; Newman, C.B.; Cole, D.G. Black women in STEM: The need for intersectional supports in professional conference spaces. *J. Negro Educ.* **2019**, *88*, 297–310. [CrossRef]
50. Conrad, S.; Canetto, S.S.; Macphee, D.; Farro, S. What attracts high-achieving socioeconomically disadvantaged students to the physical sciences and engineering? *Coll. Stud. J.* **2009**, *43*, 1359–1369.
51. Halpin, G.; Halpin, G. A promising prospect for minority retention: Students becoming peer mentors. *J. Negro Educ.* **2012**, *69*, 375–383. [CrossRef]
52. Mckimm, J.; Jollie, C.; Hatter, M. Mentoring: Theory and Practice. Preparedness to Practice Project, Mentoring Scheme. 2007. Available online: https://www.richardswanson.com/textbookresources/wp-content/uploads/2013/08/TBAD-r8-Mentoring-Theory-and-Practice-J-McKim-et-al-2007.pdf (accessed on 7 May 2024).
53. Slaughter, G.; Harris, T.; Ngandu, K.; Williamson, K.; Adom, K. Undergraduate research experience: A tool for students pursuing a graduate degree in engineering. In Proceedings of the 2009 ASEE Annual Conference and Exposition, Austin, TX, USA, 14–17 June 2009; American Society for Engineering Education: Washington, DC, USA, 2009.
54. Tate IV, W.F. Critical race theory and education: History, theory, and implications. *Rev. Res. Educ.* **1997**, *22*, 195–247. [CrossRef]
55. Bandura, A. Social cognitive theory in cultural context. *Appl. Psychol.* **2002**, *51*, 269–290. [CrossRef]
56. Bandura, A. Social cognitive theory of self-regulation. *Organ. Behav. Hum. Decis. Process.* **1991**, *50*, 248–287. [CrossRef]
57. Carbado, D.W.; Crenshaw, K.W.; Mays, V.M.; Tomlinson, B. Intersectionality: Mapping the movements of a theory. *Du Bois Rev.* **2013**, *10*, 303–312. [CrossRef] [PubMed]
58. Beilock, S.L.; Gunderson, E.A.; Ramirez, G.; Levine, S.C. Female teachers' math anxiety affects girls' math achievement. *Proc. Natl. Acad. Sci. USA* **2010**, *107*, 1860–1863. [CrossRef] [PubMed]
59. Johnston, M.P. Secondary data analysis: A method of which the time has come. *Qual. Quantative Methods Libr.* **2014**, *3*, 619–626.

60. Levitt, H.M.; Bamberg, M.; Creswell, J.W.; Frost, D.M.; Josselson, R.; Suárez-Orozco, C. Journal article reporting standards for qualitative primary, qualitative meta-analytic, and mixed methods research in psychology: The APA publications and communications board task force report. *Am. Psychol.* **2018**, *73*, 26–46. [CrossRef]
61. Cohen, A.D. *Language Learning: Insights for Learners, Teachers, and Researchers*; Newbury House Publishers: New York, NY, USA, 1990.