

Article

Investigating the Impact of STEM Inquiry-Based Learning Activities on Secondary School Student's STEM Career Interests: A Gender-Based Analysis Using the Social Cognitive Career Framework

Teresa Ribeirinha ¹, Mónica Baptista ² and Marisa Correia ^{1,*}

¹ Life Quality Research Centre, School of Education, Santarém Polytechnic University, 2001-902 Santarém, Portugal; teresa.ribeirinha@ese.ipsantarem.pt

² UIDEF, Institute of Education, University of Lisbon, 1649-013 Lisbon, Portugal; mbaptista@ie.ulisboa.pt

* Correspondence: marisa.correia@ese.ipsantarem.pt

Abstract: Gender disparity within science, technology, engineering, and mathematics (STEM) fields is a persistent global issue, with women being consistently underrepresented. Recent research indicates that inquiry-based practices may enhance students' interest in STEM careers and challenge gender-related STEM stereotypes. The aim of this study is to evaluate the impact of STEM inquiry-based learning activities on students' interest in STEM careers, as well as on the social cognitive career theory (SCCT) dimensions (self-efficacy, personal goals, outcome expectations, interests, contextual support, and personal inputs), with a specific focus on gender. A quantitative approach was employed, whereby pre- and post-test measures were administered to a cohort of 190 Portuguese secondary school students, using the STEM Career Interest Survey. The results showed that, while the STEM inquiry-based learning activities did not alter the gender-based patterns of interest in STEM subjects and careers, they did contribute to a significant increase in students' interest in these areas. It was found that these activities were particularly effective in promoting female students' interest in STEM careers. A significant increase was observed in all SCCT dimensions, particularly in engineering, for female students. Additionally, no gender disparities were observed in self-efficacy in STEM areas. The results suggest that STEM inquiry-based learning activities are an effective approach to building students' confidence in STEM fields and stimulating their interest in STEM careers. This study reinforces the importance of inquiry-based practices in promoting a more equitable STEM education landscape.

Keywords: gender differences; STEM inquiry-based learning activities; interest in STEM careers; Portuguese secondary students; social cognitive career theory



Citation: Ribeirinha, T.; Baptista, M.; Correia, M. Investigating the Impact of STEM Inquiry-Based Learning Activities on Secondary School Student's STEM Career Interests: A Gender-Based Analysis Using the Social Cognitive Career Framework. *Educ. Sci.* **2024**, *14*, 1037. <https://doi.org/10.3390/educsci14101037>

Academic Editor: Amber Simpson

Received: 8 August 2024

Revised: 19 September 2024

Accepted: 20 September 2024

Published: 24 September 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

In recent years, STEM (Science, Technology, Engineering and Mathematics) education has become a focal point of educational reforms worldwide, as it is believed to inspire students to pursue careers in these fields and equip them to address multidisciplinary and complex global challenges [1]. Despite this, the number of students choosing to study physical sciences, engineering, and mathematics at the university level has declined [2]. Additionally, even though female students constitute most undergraduate students, on average across OECD countries, they are still under-represented in STEM [3]. According to the [4] report from the National Center for Science and Engineering Statistics (NCSES), there is a notable disparity between the representation of women in the STEM workforce and their proportion within the overall U.S. population. In 2021, women constituted 51% of the total population aged 18 to 74 years and 35% of those employed in a STEM occupation. Furthermore, women and certain racial and ethnic minority groups are underrepresented

in postsecondary science and engineering education, which may be indicative of their future participation in the STEM workforce.

Wang and Degol [5] ascertained that the underrepresentation of female students in STEM education is attributed to factors such as lifestyle values, work–life balance preferences, beliefs regarding field-specific abilities, and the presence of gender-related stereotypes and biases. In general, female students are slightly more likely to perceive STEM studies as “difficult and confusing” and are less likely to believe that they are proficient in these subjects [6,7]. This leads them to experience concern that they do not fit the stereotype of STEM professionals and to hold the belief that they lack the ability to succeed in these areas [8].

The Social Cognitive Career Theory (SCCT) [9] posits those contextual factors, such as school-based learning experiences and social influences, play an important role in shaping career interests in STEM fields. In this context, students’ aspirations to pursue STEM careers can be shaped by the quality of classroom instruction, which provides meaningful and engaging learning experiences that inspire or equip them for such careers [10]. Social influences also contribute to this process by providing support, encouragement, and role models, as well as knowledge dissemination and career guidance [11].

Therefore, teachers need to promote STEM careers in the classroom from elementary to secondary level by engaging students in STEM activities in class. This approach can influence their interest in the field and increase their self-efficacy before they enter higher education [12]. Furthermore, introducing students to STEM education at an early age, by integrating engineering with physical sciences, mathematics, and technology, can effectively foster career interest among female students in these fields [13].

Educators and researchers have turned their attention to affective factors, such as student interest, to better understand STEM learning and motivation, highlighting the need for effective measures of STEM interest that enable tracking over time and provide opportunities for early interventions by educators [14]. One example is the STEM Career Interest Survey (STEM-CIS) instrument, which helps researchers, professional developers, and program evaluators measure the effects of their STEM programs on changes in student interest in STEM subjects and careers. This tool has significant implications for designing and improving STEM interventions [15]. Kier et al. [15] applied SCCT [9], based on Bandura’s general Social Cognitive Theory [16], to develop a survey featuring subscales for science, technology, engineering, and mathematics. The application of the STEM-CIS questionnaire has enabled researchers (e.g., [17]) to demonstrate that the development of STEM career interest significantly depends on contextual factors, outcome expectations, personal inputs, and self-efficacy, aligning with the dimensions of SCCT.

Although some studies have analyzed the impact of STEM programs on student interest using the STEM-CIS questionnaire (e.g., [18]), there has been limited attention to the specific context of active methodologies associated with STEM education, such as project-based, problem-based, or inquiry-based learning [19,20]. The present study is designed to identify changes in students’ interest in STEM careers and in the SCCT dimensions following the implementation of STEM inquiry-based learning activities with secondary school students.

2. Theoretical Framework

Curricula and learning materials play a crucial role in fostering female students’ interest and engagement in STEM subjects and providing student-centered strategies, such as inquiry are essential [3,21,22]. Several studies (e.g., [23]) have shown that STEM interventions based on inquiry-based instruction led to significant improvements in science process skills, science concepts, and science content knowledge among students. Research also suggests that inquiry-based practices may enhance students’ interest in STEM subjects and increase their interest in STEM careers [24–26]. Additionally, this approach can help alter gender-related STEM stereotypes, highlight the relevance of STEM to social life, and ultimately meet the future needs of a highly skilled STEM workforce [27].

Inquiry-based learning (IBL) is fundamentally viewed as a method of acquiring knowledge through a series of actions that mirror the typical processes used in scientific work that scientists follow to solve problems in real-world situations [28]. Students engage as scientists by planning investigations, critically analyzing data, discussing findings with peers, and developing evidence-based explanations to address the initial questions posed [29,30]. According to de Jong [31], in IBL, unlike traditional instruction where teachers explain theory and students do exercises, students take the initiative by first exploring and then collaboratively developing concepts and laws with their teachers, building on essential foundational knowledge. A key aspect of IBL is its adherence to a model proposed by Bybee [32–34] represented by the 5Es: Engage, Explore, Explain, Elaborate, and Evaluate.

Participating in STEM programs in secondary school can decrease the gender gap and mitigate the influence of family background on students' interest in pursuing STEM fields in the future [10]. Research, including that by Nugent et al. [35], indicates that involvement in STEM-related activities and school experiences can predict STEM career choices across different age groups and genders. Particularly, because such interventions frequently work only for girls with high confidence in their ability to do well in STEM subjects [36]. Therefore, investigating how inquiry learning activities impact students' interest in science and STEM career intentions is crucial for developing educational strategies that enhance students' engagement in STEM [37]. Although some studies, such as Gkagkas and Hatzikraniotis [38], have shown the effectiveness of IBL in fostering student engagement, further research is needed to identify the factors influencing students' willingness to engage in STEM activities and their likelihood of choosing STEM-related careers.

To broaden participation in STEM, it is essential to carefully measure the impact of educational interventions on student perspectives. Adolescence is a critical period for assessing these interventions, as students develop self-beliefs and make long-lasting career decisions. Hence, an effective instrument should be sensitive to these interventions by measuring dynamic beliefs and attributes, and it should be concise enough for practical implementation by teachers in a classroom setting [39].

Recent years have seen significant progress in developing instruments to measure students' attitudes and interests in STEM careers. Notable examples include the Career Interest Questionnaire (CIQ) [40,41] and the STEM-CIS [15], which assesses self-efficacy, outcome expectations, personal inputs, contextual supports and barriers, interests and goals as predictors of STEM career interest among students. STEM-CIS is grounded in the constructs of SCCT to better understand the knowledge and interest in STEM fields [42].

SCCT is a career-oriented theory that posits self-efficacy and outcome beliefs work together to predict career aspirations. According to Lent et al. [43], "SCCT focuses on several cognitive-person variables (e.g., self-efficacy, outcome expectations, and goals), and how these variables interact with other aspects of the person and his or her environment (e.g., gender, ethnicity, social supports, and barriers) to help shape the course of career development" (p. 36).

Among the variables employed in the SCCT, self-efficacy was the subject of most research studies, as it is related to academic performance and is a key factor in models of retention and persistence [44]. Self-efficacy can be defined as a dynamic set of self-beliefs connected to specific performance domains (e.g., science) and can be understood as personal judgments of one's capabilities to organize and execute courses of action to attain designated goals [16].

Outcome expectations can be defined as beliefs about the consequences of a specific course of action [9]. In contrast to self-efficacy beliefs, which concern an individual's capabilities, outcome expectations pertain to the imagined outcomes of a particular practice.

Personal goals refer to an individual's intention to perform a certain activity or achieve a certain result [16].

The SCCT model postulates that personal inputs (e.g., gender and grade) and background factors (e.g., family and school) influence individuals' learning experiences, which, in turn, shape their self-efficacy and outcome expectations; these, in turn, inform their career

interests, goals and actions [9]. It is, therefore, important to note that self-efficacy beliefs are subject to change and are receptive to information from four sources: performance accomplishment (mastery experiences), vicarious learning (stemming from observing successful social models), social persuasion (observed when instructors clarify or affirm students' abilities, thereby increasing their confidence), and physiological arousal (emotional states triggered during the learning process) [16]. Consequently, success experiences were found to enhance self-efficacy beliefs, whereas repeated failures were found to diminish them.

SCCT is particularly effective in understanding the gender gap in STEM because it identifies factors influencing students' success in these fields, such as the widening gender gap in academic self-efficacy as students age [45]. This theory also highlights elements related to career interest, which are closely tied to individuals' self-efficacy and confidence in their ability to perform STEM-related tasks [46].

Some previous studies identified changes in interest toward STEM subjects and interest in pursuing STEM careers after participating in integrated STEM education programs, using STEM-CIS in secondary school settings [18,19,47,48]. Most studies described the implementation of out-of-school or after-school STEM programs [47,49,50] and only a few focused on the impact of STEM activities on the STEM career choices of female students [48]. It is, therefore, important to conduct further research into the impact of STEM inquiry activities in the classroom on the interest of female secondary students in STEM subjects and their subsequent pursuit of careers in these fields. Thus, to advance knowledge in this field, the objective of this study is to evaluate the influence of STEM inquiry-based learning activities on students' interest in STEM subjects and careers, with a particular focus on gender using pre-test and post-test measures for a group of participants. The STEM-CIS was used to assess participants' interest in STEM subjects and careers and to explore the dimensions of the SCCT (self-efficacy, outcome expectations, interests, goals, contextual supports and personal inputs).

3. Materials and Methods

3.1. Participants

A convenience sampling approach was employed to select 190 students from 12th-grade chemistry classes during the 2022/2023 academic year. The participants were recruited from three secondary educational establishments situated in Lisbon, Portugal. The sample consisted of 85 male students (44.5%) and 106 female students (55.5%). The average age of the students was 17.2 years; SD = 0.52.

3.2. Instruments

The STEM-CIS survey, developed by Kier et al. [15], was adapted for this study to investigate the interest in STEM subjects and careers of students in upper secondary schools. The STEM-CIS survey was chosen because it considers all STEM subjects (science, technology, engineering, and mathematics) and utilizes the SCCT framework. The original questionnaire consists of 44 items, which are rated on a 5-point Likert scale, ranging from "strongly disagree" to "strongly agree". It comprises four discipline-specific subscales: Science (S), Technology (T), Engineering (E), and Mathematics (M). Each subscale comprised 11 items addressing six social cognitive career dimensions: self-efficacy, personal goals, outcome expectations, interests, contextual supports (comprising two items each), and personal inputs (represented by one item).

Kier et al. [15] validated the STEM-CIS with a population of 1000 middle school students. The results of the confirmatory factor analysis indicated that the STEM-CIS is a strong instrument, and its items are effective in measuring interest in STEM. According to the authors, the Cronbach's alpha for STEM-CIS typically ranges between 0.77 and 0.89 for the subscales.

The original version of the survey instrument was translated into Portuguese. The Portuguese survey also included demographic questions, including the gender of the respondents. To ensure the survey instruments could be read and understood, five high

school students were invited to complete the questionnaire and provide feedback on the instructions, question format, and wording. Based on their feedback, additional revisions were made before the survey instruments were finalized and administered to the participants.

The survey was administered in person under the supervision of the researchers. Before administering the questionnaire, a brief description of the purpose of the study and an informed consent process were given to the participants. The questionnaire took about 15 min to complete.

An exploratory principal component factor analysis was performed, and Cronbach's alpha was determined to ensure the construct validity and reliability of the instrument in the sample of secondary school students. The results showed that the sample adequacy was good (KMO = 0.814); through Barlett's test of sphericity (sig. < 0.001), the fit of the variables or dimensions of the STEM-CIS is also guaranteed by the factor analysis. Conversely, the four dimensions collectively account for 54.8% of the explained variance. Cronbach's alpha for each dimension is high: α (S) = 0.86; α (T) = 0.83; α (E) = 0.92; α (M) = 0.86. Finally, the validity and reliability of the instrument were confirmed with an alpha of 0.94.

3.3. Procedure

This study employed a quantitative approach, utilizing pre-test and post-test measures for a group of participants. The objective was to ascertain whether the implementation of STEM inquiry-based learning activities had an impact on their interests in pursuing STEM careers, as well as on the SCCT dimensions. The independent variable was the STEM inquiry-based learning activities, while the dependent variable was the interest in pursuing STEM careers. The data were gathered utilizing the STEM-CIS questionnaire [15], which gauged interest in pursuing a career in STEM according to the time of application (pre-test and post-test) and the gender variable. The pre-test was administered to the students at the beginning of the classes (September) to determine the students' pre-existing interest in STEM subjects and careers. The post-test was administered to the students after they had participated in the STEM inquiry-based learning activities (May). The pre- and post-tests were matched using the students' identification numbers.

The students participated in a sequence of STEM inquiry-based learning activities on the topic of 'Fossil Fuels', following the 5Es model by Bybee et al. [34]. The sequence began with an everyday situation related to the refining industry to enhance pupils' curiosity about the theme (Engage phase). After that, students researched the topic online, used educational animations to understand the compounds acquired through crude oil distillation, and constructed a prototype of an industry that included a crude oil distillation column. During this process, students developed plans, constructed a model, created a prototype, and tested and refined the prototype. Additionally, as students developed their prototypes, teachers introduced questions to help students improve their plans, models, and prototypes. These questions were associated with catalytic cracking and its importance in the crude oil refining industry, as well as the production of petrol used in combustion engines. During the development of the refinery prototypes, students watched videos about this type of industry, played games about hydrocarbons, and consulted various websites, some of which included Portuguese legislation regulating this type of industry (Explore phase). Finally, students were required to explain the process of crude oil distillation considering the prototype constructed (Explain phase). Furthermore, they had to build a global understanding of the topic, facilitating the selection of the most important issues to communicate to others in a simple and stimulating way (Elaborate phase). Lastly, students evaluated the work carried out (evaluation phase), reflecting on what they had learned, difficulties met and overcome, group work, what they liked the most and the least, and what they would like to learn more about. This reflection is extremely important, as it allows students to evaluate their actions and the efficiency of the learning processes. The learning sequence is part of the Year 12 chemistry curriculum. The STEM inquiry-based learning activities were carried out by five chemistry teachers who had participated in

STEM education training. The sequence of activities and their implementation with the students was planned by the researchers together with the teachers. To carry out the activities, the teachers of the participating classes organized the pupils into groups of 4 or 5 during six 90 min lessons.

3.4. Data Analysis

The data were analyzed using Jamovi[®] 2.2.5.0 software. The value of 0.05 was used as the significant level for interpreting the results. The data were not normally distributed (Shapiro–Wilk ≤ 0.05), therefore, non-parametric tests were used to analyze the data.

Four mean scores were calculated from the STEM-CIS data for discipline-specific STEM interest (subscales) and for each SCCT dimension (e.g., science self-efficacy, technology self-efficacy and mathematics self-efficacy). Mean scores for the discipline-specific subscales were calculated by summing the ratings for each subscale and dividing by the total number of items included in the subscale (11 items). The same procedure was applied to the means of the SCCT dimensions. The Mann–Whitney U test was used to assess the effect of gender on discipline-specific STEM interest and on the six SCCT dimensions for each discipline-specific subscale. To determine whether the implementation of STEM inquiry-based learning activities had an impact on the student’s interest in STEM careers, pairwise comparisons were made between the pre- and post-test scores for discipline-specific STEM interests and for each SCCT dimension. For this purpose, the Wilcoxon test was used, controlling for family-wise error across the tests at the 0.013 level using the Bonferroni correction.

4. Results

4.1. Pre-Test

As shown in Table 1, the mean level of interest of female students in STEM subjects and careers ranged from 3.22 (engineering) to 3.72 (science). The mean level of interest among male students in STEM subjects and careers ranged from 3.43 (engineering) to 3.78 (technology). The results demonstrated a statistically significant discrepancy in students’ career interest in science, technology, and engineering based on gender [science: $U(188) = 3718; p = 0.013$; technology: $U(188) = 3505; p = 0.012$; engineering: $U(188) = 3465; p = 0.012$]. Therefore, female students demonstrated a greater career interest in science than male students. Conversely, male students exhibited a higher level of career interest in engineering and technology than their female counterparts.

Table 1. Descriptive statistics (mean and standard deviation) and Mann–Whitney U test results for discipline-specific subscales (pre-test).

		Science	Technology	Engineering	Mathematics
Gender	Female	3.72 (0.66)	3.56 (0.65)	3.22 (0.72)	3.62 (0.67)
	Male	3.47 (0.74)	3.78 (0.67)	3.43 (0.89)	3.64 (0.68)
Mann–Whitney U	Statistic	3718	3505	3456	4367
	p	0.013 *	0.012 *	0.012 *	0.821
	Effect Size r	0.366	0.213	0.212	

* Statistically significant.

A statistically significant gender difference was also identified in all dimensions when the questionnaire was analyzed in terms of the SCCT dimensions for each discipline-specific subscale (Table 2). Specifically, male students exhibited higher personal goals, outcome expectations and interests for engineering [$U(188) = 3586; p = 0.019$; $U(188) = 3488; p = 0.011$; $U(188) = 3305; p = 0.003$] and technology [$U(188) = 3720; p = 0.047$; $U(188) = 3285; p = 0.001$; $U(188) = 1377; p = 0.029$] than female students. Additionally, male students demonstrated higher self-efficacy for engineering than female students [$U(188) = 3673; p = 0.034$], while female students exhibited higher contextual supports and personal inputs for science [$U(188) = 3488; p = 0.007$; $U(188) = 3712; p = 0.041$].

Table 2. Descriptive statistics (mean and standard deviation) and Mann–Whitney U test results for SCCT dimensions (pre-test).

			Science	Technology	Engineering	Mathematics
self-efficacy	Gender	Female	4.00 (0.63)	3.88 (0.59)	3.18 (0.91)	3.75 (0.89)
		Male	3.85 (0.69)	3.91 (0.78)	3.42 (1.01)	3.76 (0.83)
	Mann–Whitney U	Statistic	3894	4218	3673	4449
		<i>p</i>	0.126	0.520	0.034 *	0.995
		Effect Size <i>r</i>	--	--	0.175	--
personal goals	Gender	Female	3.83 (0.76)	3.71 (0.80)	3.06 (0.90)	3.87 (0.83)
		Male	3.61 (0.75)	3.95 (0.82)	3.36 (1.09)	3.83 (0.79)
	Mann–Whitney U	Statistic	3751	3720	3586	4275
		<i>p</i>	0.058	0.047 *	0.019 *	0.633
		Effect Size <i>r</i>	--	0.164	0.194	--
Outcome expectations	Gender	Female	3.58 (0.92)	3.14 (1.08)	3.03 (1.13)	3.66 (0.83)
		Male	3.48 (0.95)	3.65 (1.07)	3.43 (1.22)	3.78 (0.88)
	Mann–Whitney U	Statistic	4281	3285	3488	4063
		<i>p</i>	0.646	0.001 *	0.011 *	0.294
		Effect Size <i>r</i>	--	0.262	0.207	--
Interests	Gender	Female	3.58 (0.99)	3.65 (0.74)	2.96 (1.04)	3.37 (0.98)
		Male	3.32 (1.03)	3.95 (0.87) *	3.41 (1.18) *	3.50 (0.95)
	Mann–Whitney U	Statistic	3855	1377	3305	4055
		<i>p</i>	0.109	0.029 *	0.003 *	0.287
		Effect Size <i>r</i>	--	0.228	0.249	--
contextual supports	Gender	Female	3.54 (1.09) *	3.51 (1.08)	3.54 (1.03)	3.56 (0.97)
		Male	3.09 (1.05)	3.50 (0.98)	3.41 (0.99)	3.27 (0.96)
	Mann–Whitney U	Statistic	3448	4353	4062	3730
		<i>p</i>	0.007 *	0.790	0.293	0.052
		Effect Size <i>r</i>	0.226	--	--	--
Personal inputs	Gender	Female	3.87 (1.02) *	3.61 (1.01)	3.57 (0.99)	3.67 (1.06)
		Male	3.43 (1.32)	3.79 (1.13)	3.62 (1.25)	3.51 (1.01)
	Mann–Whitney U	Statistic	3712	3976	4098	4213
		<i>p</i>	0.041 *	0.187	0.327	0.509
		Effect Size <i>r</i>	0.166	--	--	--

* Statistically significant.

4.2. Post-Test

According to Table 3, the mean level of interest of female students in STEM subjects and careers, following the implementation of integrated STEM activities, ranged from 3.34 (engineering) to 3.74 (science). The mean level of interest among male students in STEM subjects and careers ranged from 3.50 (science) to 3.83 (technology). There was a statistically significant difference by gender in students' career interest in science [$U(188) = 3556$; $p = 0.022$], technology [$U(188) = 3644$; $p = 0.032$] and engineering [$U(188) = 3582$; $p = 0.029$]. Thus, following the implementation of STEM inquiry-based learning activities, the level of interest of female students in science remained higher than that of male students. In the field of engineering and technology, the interest level of male students continued to be higher than that of female students.

A post-test analysis of the SCCT dimensions for each subject-specific subscale (Table 4) revealed that the personal goals, outcome expectations, interests, contextual supports and personal inputs dimensions continue to demonstrate statistically significant gender differences. On the other hand, there was no gender difference in the self-efficacy dimension. More specifically, male students had higher outcome expectations and interests for engineering [$U(188) = 3535$; $p = 0.014$; $U(188) = 3446$; $p = 0.007$] and technology [$U(188) = 3414$; $p = 0.004$; $U(188) = 3266$; $p = 0.001$] than girls. In addition, male students showed higher

personal goals for engineering [$U(188) = 3701; p = 0.043$] than female students, while female students continued to show higher contextual supports and personal inputs for science [$U(188) = 3456; p = 0.007; U(188) = 3739; p = 0.049$].

Table 3. Descriptive statistics (mean and standard deviation) and Mann–Whitney U test results for discipline-specific subscales (post-test).

		Science	Technology	Engineering	Mathematics
Gender	Female	3.74 (0.64)	3.63 (0.60)	3.34 (0.65)	3.68 (0.63)
	Male	3.50 (0.71)	3.83 (0.61)	3.51 (0.84)	3.66 (0.64)
Mann–Whitney U	Statistic	3556	3644	3582	4359
	p	0.022 *	0.032 *	0.029 *	0.806
	Effect Size r^2	0.199	0.182	0.186	

* Statistically significant.

Table 4. Descriptive statistics (mean and standard deviation) and Mann–Whitney U test results for SCCT dimensions (post-test).

		Science	Technology	Engineering	Mathematics	
self-efficacy	Gender	Female	4.02 (0.60)	3.89 (0.60)	3.25 (0.91)	3.80 (0.79)
		Male	3.85 (0.68)	3.96 (0.72)	3.46 (1.01)	3.78 (0.84)
	Mann–Whitney U	Statistic	3864	4134	3782	4462
		p	0.108	0.381	0.06	0.945
		Effect Size r				
personal goals	Gender	Female	3.84 (0.75)	3.76 (0.78)	3.16 (0.87)	3.89 (0.80)
		Male	3.67 (0.72)	3.98 (0.77)	3.42 (1.11) *	3.89 (0.77)
	Mann–Whitney U	Statistic	3856	3807	3701	4379
		p	0.106	0.079	0.043	0.844
		Effect Size r		0.169		
Outcome expectations	Gender	Female	3.60 (0.89)	3.19 (1.03)	3.26 (0.95)	3.68 (0.79)
		Male	3.49 (0.94)	3.63 (1.01) *	3.59 (1.02) *	3.78 (0.86)
	Mann–Whitney U	Statistic	4271	3414	3535	4130
		p	0.626	0.004	0.014	0.384
		Effect Size r		0.233	0.196	
Interests	Gender	Female	3.58 (0.97)	3.58 (0.68)	3.21 (0.84)	3.40 (0.91)
		Male	3.35 (0.99)	3.93 (0.81) *	3.52 (0.99) *	3.57 (0.90)
	Mann–Whitney U	Statistic	3899	3266	3446	3903
		p	0.137	0.001	0.007	0.140
		Effect Size r		0.266	0.226	
contextual supports	Gender	Female	3.57 (1.07)	3.63 (0.99)	3.66 (0.91)	3.59 (0.91)
		Male	3.14 (1.02)	3.61 (0.89)	3.48 (0.92)	3.32 (0.91)
	Mann–Whitney U	Statistic	3456	4348	3935	3752
		p	0.007	0.779	0.162	0.059
		Effect Size r	0.223			
Personal inputs	Gender	Female	3.93 (0.94)	3.71 (1.03)	3.62 (0.96)	3.72 (1.03)
		Male	3.51 (1.28)	3.82 (1.10)	3.68 (1.19)	3.55 (1.18)
	Mann–Whitney U	Statistic	3739	4073	4120	4184
		p	0.049	0.293	0.357	0.459
		Effect Size r	0.1602			

* Statistically significant.

4.3. Pre-Test Post-Test Comparison

A comparison of the pre-test and post-test means for female students' discipline-specific STEM career interest, as determined by the Wilcoxon test, revealed a statistically

significant difference in female students' interest in mathematics [$W(105) = 69.0; p = 0.002$], technology [$W(105) = 26.5; p < 0.001$] and engineering [$W(105) = 26.5; p < 0.001$] (see Appendix A Table A1). It can, therefore, be said that female students' interest in mathematics, engineering, and technology increased after the STEM inquiry-based learning activities.

A Wilcoxon test was also employed for the purpose of conducting a comparative analysis of the female students' pre-test and post-test results for each of the SCCT dimensions (see Appendix A Table A2). The results demonstrated statistically significant differences across all dimensions. In particular, the data indicated that following the STEM inquiry-based learning activities female students exhibited increased levels of self-efficacy [$W(105) = 36.0; p = 0.012$], personal goals [$W(105) = 55.0; p = 0.005$], outcome expectations [$W(105) = 120; p = 0.001$], interests [$W(105) = 190; p = 0.001$] and contextual supports [$W(105) = 117.5; p = 0.010$] for engineering. Moreover, they demonstrated an enhanced level of contextual support [$W(105) = 94.5; p = 0.009$] and personal input [$W(105) = 45.0; p = 0.005$] for technology.

Regarding the male participants, the Wilcoxon test demonstrated a statistically significant difference in their interest in science [$W(83) = 13.5; p = 0.002$] and engineering [$W(83) = 8.00; p = 0.002$] following the STEM inquiry-based learning activities (see Appendix A Table A3). It can thus be posited that the level of interest in science and engineering among male students increased following the implementation of STEM inquiry-based learning activities. A Wilcoxon test was also used to conduct a comparative analysis of the males' pre- and post-test scores for each of the SCCT dimensions (see Appendix A Table A4). The results showed statistically significant differences in personal goals, outcome expectations and contextual supports. In particular, the data indicated that following the STEM inquiry-based learning activities, male students exhibited increased levels of personal goals [$W(83) = 50.5; p = 0.008$] for science, outcome expectations [$W(83) = 34.50; p = 0.011$] for engineering and contextual supports [$W(105) = 64.0; p = 0.003$] for technology.

5. Discussion

The objective of this study was to evaluate the influence of STEM inquiry-based learning activities on students' interest in STEM subjects and careers, with a particular focus on gender. The STEM-CIS pre- and post-tests were used to assess students' interest in STEM subjects and careers and to explore changes in the dimensions of the SCCT (self-efficacy, outcome expectations, interests, goals, contextual supports and personal inputs).

Prior to the implementation of the STEM inquiry-based learning activities, the results of the pre-test indicated the presence of gender-based differences in students' interest in STEM subjects and careers. These differences align with the global pattern previously identified in the extant literature, suggesting that male students exhibit greater interest in technology and engineering-related careers, while female students demonstrate a stronger inclination towards science-oriented careers [10,13].

Upon analysis of the pre-test results in accordance with the dimensions of the SCCT, it was discerned that in science, gender differences were observed in favor of female students regarding the contextual supports and personal inputs dimensions. Conversely, in the domain of technology and engineering, the gender differences were in favor of male students. In the domain of technology, these differences were observed in the personal goals, outcome expectations, and interest dimensions. In engineering, in addition to these three dimensions, the self-efficacy dimension also demonstrated significant differences. Gender differences in ability beliefs, particularly self-efficacy, are acknowledged as a pivotal factor contributing to the STEM gender gap [36]. Research demonstrates that female student's self-efficacy in STEM fields is consistently lower than that of male students, even though women often achieve higher levels of performance in these domains [7,45]. This discrepancy may be attributed, at least in part, to the different ways in which male and female students interpret information related to their academic performance [7]. Female students' interpretations related to their academic performance are shaped by a combination of vicarious experience and social persuasion, including the influence of others' judgments,

feedback, and support. In contrast, male students' interpretations are more influenced by personal mastery experiences [44,51].

Following the introduction of STEM inquiry-based learning activities, the results of the post-test exhibited a similar pattern of interest in STEM careers as observed in the pre-test. Gender differences persisted in science, in favor of female students, and in technology and engineering, in favor of male students. However, post-test results analyses using the dimensions of the SCCT showed that the initial gender difference in the self-efficacy dimension for engineering (in favor of male students) was no longer statistically significant, and the same was true for the personal goals dimension for technology. According to Bandura [16], self-efficacy beliefs can be modified based on information derived from performance accomplishment, the influence of others' judgments, feedback and support. This information shapes efficacy beliefs by influencing an individual's subjective interpretation of their performance on specific tasks [16]. It can, therefore, be hypothesized that the successful and supported completion of STEM inquiry-based learning activities by female students may have a positive effect on their interpretation of their performance, which may, in turn, be associated with an increase in self-efficacy beliefs for engineering and the setting of personal goals for technology. This hypothesis is supported by the results of the comparison between the pre-test and post-test by gender, which showed a significant increase in the interest of female students in technology (higher scores on the dimensions of contextual supports and personal inputs than those observed in the pre-test), engineering (higher scores on the dimensions of self-efficacy, outcome expectations, interests, personal goals and contextual supports than those observed in the pre-test) and mathematics careers. It can, therefore, be argued that the inclusion of STEM inquiry-based learning activities increased female students' interest in pursuing careers in engineering, technology and mathematics, possibly because these activities provided them with the necessary feedback and support, thereby giving them a sense of confidence in their abilities to excel in STEM-related fields. This finding lends support to the notion that inquiry-based pedagogical approaches may foster greater interest among students in STEM subjects, enhance their engagement with STEM careers [24–26] and increase their self-efficacy [12]. Additionally, it is consistent with other research that indicates that the outcomes of students' engagement in STEM are particularly significant for female students, who exhibit more pronounced positive changes in both perceived ability and career aspirations compared to their male counterparts [41].

Nevertheless, the implementation of STEM inquiry-based learning activities also influenced male students' interest in STEM careers. Following the introduction of these activities, there was a significant increase in male students' interest in engineering (higher scores on the dimension of outcome expectations than those observed in the pre-test) and science (higher scores on the dimensions of personal goals than those observed in the pre-test) careers. Thus, the STEM inquiry-based learning activities not only stimulated greater interest in subjects in which male students displayed less interest than their female counterparts (science), but also in subjects in which male students exhibited greater interest than their female counterparts (engineering). The SCCT provides an insight into this phenomenon, suggesting that emerging interests give rise to intentions or goals that lead to greater exposure to the activity, which in turn increases the likelihood that the student will select and practice tasks in that domain [9]. This result underscores the importance of promoting and sustaining students' interest in STEM subjects and careers. Furthermore, a consistent pattern emerges when analyzing the dimensions of the SCCT that favor male students, both in the pre-test and post-test results. This pattern includes the dimensions of interest and outcome expectations. Unlike female students, males' decisions to pursue a STEM career are not significantly influenced by their self-perceived ability to excel in STEM areas; instead, their decision to pursue a particular program is primarily driven by their interest in STEM subjects [36].

It was, therefore, evident that well-structured STEM inquiry-based learning activities, which provided students with the opportunity to address a real-world problem by applying their STEM knowledge and skills, were an effective method of fostering students' confi-

dence in STEM fields and increasing their interest in pursuing STEM careers. The findings of the present study provide evidence that progress can be made toward eliminating the existing gender gap in interest in STEM careers. The implications of these findings for attracting more female students into STEM are consistent with previous suggestions in the literature and may facilitate more targeted interventions [5,6,44]. Central to this discussion is the importance of STEM-specific self-efficacy and interest, together with other likely mediators of gender differences in STEM careers (e.g., social influences). Such suggestions may include various intervention strategies that have been shown to foster interest in STEM fields and facilitate mastery experiences (such as hands-on and inquiry-based approaches), expose female students to successful peer role models, and provide positive goal-directed formative feedback. Additionally, educators must take action to expand career opportunities for female students. This can be achieved by leveraging their cognitive strengths, emphasizing effort over talent, and addressing the impact of male stereotypes, misinformation, and barriers to career choices.

6. Conclusions

The objective of this study was to evaluate the influence of STEM inquiry-based learning activities on students' interest in STEM subjects and careers, with a particular focus on gender.

The STEM inquiry-based learning activities had no discernible impact on the gender patterns of interest in STEM careers. However, they did succeed in increasing students' interest in pursuing STEM careers. Furthermore, the STEM inquiry-based learning activities were found to be particularly effective in enhancing STEM career interests among female students. Following their participation in STEM activities, female students demonstrated a significant increase in all SCCT dimensions, particularly in engineering. Additionally, no gender disparities were observed in self-efficacy in STEM subjects, and the initial gender gap in technology-related personal goals disappeared. Therefore, actively involving students in authentic activities similar to those undertaken by professionals has great potential to build students' confidence in STEM fields and increase their interest in pursuing STEM careers.

These findings highlight the pivotal role of STEM education in fostering and maintaining students' interest in STEM careers. They also suggest the implementation of targeted interventions designed to instill confidence in female students, thereby ensuring that they possess the requisite skills to succeed in a STEM career.

However, it should be noted that the findings of this study are not necessarily representative of the wider population, due to certain limitations inherent to the methodology employed. Nevertheless, it offers some guidance for future research. The first limitation pertains to the fact that the study involved only one group and a relatively small number of participants (190). As the study design did not include a control group, it is not possible to attribute the observed results exclusively to STEM inquiry-based learning activities. It is, therefore, recommended that future studies adopt a quasi-experimental design with experimental and control groups, as well as a larger number of participants. The second limitation concerns the sample of participants, which only included volunteer students from three schools located in the same urban area of the country. Consequently, the findings may not be representative of the secondary school student population in Portugal. A further limitation is that the STEM inquiry-based learning activities have a focus on science, particularly chemistry, were implemented by chemistry teachers, and have a relatively short implementation period. This may have contributed to a bias toward science (in particular, chemistry). It is possible that the results may reflect improvements or engagement in science to a greater extent than holistic development in all STEM areas. As the implementation period was relatively short (six 90 min lessons), it may not have been long enough to observe long-term effects on students' interest. In addition, the novelty effect may have influenced students' initial enthusiasm and engagement, which may not be sustained over a longer period. It would be beneficial for future research to consider cross-curricular activities, interdisciplinary teaching teams, and longer implementation periods to better assess the sustainability and impact of these activities.

Author Contributions: Conceptualization, T.R.; methodology, T.R.; software, T.R.; validation, all authors; formal analysis, M.C.; investigation, M.B.; data curation, T.R.; writing—original draft preparation, all authors; writing—review and editing, all authors; project administration, M.B. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by national Funds through FCT—Portuguese Foundation for Science and Technology, I.P., under the scope of: Life Quality Research Centre (CIEQV) (UIDP/04748/2020), and UIDEF—Unidade de Investigação e Desenvolvimento em Educação e Formação, UIDB/04107/2020, <https://doi.org/10.54499/UIDB/04107/2020>.

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of the Institute of Education of the University of Lisbon (protocol code 4001, 6 October 2000).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Due to ethical issues, the data collected and analyzed in this study are not available to outside researchers.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Descriptive statistics (mean and standard deviation) and Wilcoxon W test results for female students discipline-specific subscales (N = 106).

	Science	Technology	Engineering	Mathematics
pre	3.72 (0.66)	3.56 (0.65)	3.22 (0.73)	3.64 (0.68)
post	3.74 (0.64)	3.63 (0.60)	3.43 (0.65)	3.68 (0.63)
Statistic	155.5	26.5	26.5	69.0
<i>p</i>	0.040	<0.001 ^a	<0.001 ^b	0.002 ^c

* Statistically significant; ^a: 79 pairs of values were tied; ^b: 68 pairs of values were tied; ^c: 78 pairs of values were tied.

Table A2. Descriptive statistics (mean and standard deviation) and Wilcoxon W test results for female students SCCT dimensions (N = 106).

	Science	Technology	Engineering	Mathematics	
self-efficacy	pre	4.00 (0.60)	3.88 (0.59)	3.18 (0.91)	3.75 (0.89)
	post	4.02 (0.63)	3.89 (0.60)	3.25 (0.91)	3.80 (0.80)
	Statistic	106.0	13.0	36.0	4462
	<i>p</i>	0.349	0.665	0.012 ^a	0.945
personal goals	pre	3.83 (0.75)	3.71 (0.80)	3.06 (0.90)	3.87 (0.82)
	post	3.84 (0.75)	3.76 (0.77)	3.16 (0.87)	3.89 (0.80)
	Statistic	17.5	15.0	55.0	28.0
	<i>p</i>	0.588	0.057	0.005 ^b	0.164
Outcome expectations	pre	3.58 (0.93)	3.14 (1.08)	3.03 (1.13)	3.66 (0.84)
	post	3.60 (0.89)	3.19 (1.03)	3.26 (0.95)	3.68 (0.80)
	Statistic	18.0	28.0	120.0	22.0
	<i>p</i>	0.120	0.152	<0.001 ^c	0.187
Interests	pre	3.58 (0.99)	3.65 (0.74)	3.03 (0.94)	3.37 (0.98)
	post	3.58 (0.98)	3.68 (0.71)	3.21 (0.84)	3.40 (0.91)
	Statistic	9.00	6.50	190.0	26.5
	<i>p</i>	0.824	0.710	<0.001 ^d	0.254
contextual supports	pre	3.54 (1.09)	3.51 (1.08)	3.54 (1.03)	3.56 (0.97)
	post	3.57 (1.07)	3.63 (0.99)	3.66 (0.91)	3.59 (0.91)
	Statistic	15.0	94.5	117.5	16.5
	<i>p</i>	0.053	0.009 ^e	0.010 ^f	0.242
Personal inputs	pre	3.87 (1.02)	3.61 (1.02)	3.57 (0.99)	3.67 (1.06)
	post	3.93 (0.94)	3.71 (1.03)	3.62 (0.96)	3.72 (1.03)
	Statistic	10.0	45.0	29.0	15.0
	<i>p</i>	0.098	0.005 ^g	0.124	0.037

* Statistically significant; ^a: 98 pairs of values were tied; ^b: 96 pairs of values were tied; ^c: 91 pairs of values were tied; ^d: 87 pairs of values were tied; ^e: 92 pairs of values were tied; ^f: 90 pairs of values were tied; ^g: 97 pairs of values were tied.

Table A3. Descriptive statistics (mean and standard deviation) and Wilcoxon W test results for male students discipline-specific subscales (N = 85).

	Science	Technology	Engineering	Mathematics
pre	3.47 (0.74)	3.78 (0.67)	3.43 (0.90)	3.62 (0.68)
post	3.50 (0.71)	3.83 (0.61)	3.51 (0.84)	3.66 (0.64)
Statistic	13.50	17.50	8.00	40.00
<i>p</i>	0.002 ^{*a}	0.030	0.002 ^{*b}	0.087

* Statistically significant; ^a: 66 pairs of values were tied; ^b: 67 pairs of values were tied.

Table A4. Descriptive statistics (mean and standard deviation) and Wilcoxon W test results for male students SCCT dimensions (N = 85).

		Science	Technology	Engineering	Mathematics
self-efficacy	pre	3.85 (0.69)	3.91 (0.78)	3.42 (1.01)	3.76 (0.83)
	post	3.85 (0.68)	3.96 (0.72)	3.46 (1.02)	3.78 (0.84)
	Statistic	48.0	9.00	15.00	22.5
	<i>p</i>	0.442	0.101	0.027	0.283
personal goals	pre	3.61 (0.75)	3.95 (0.83)	3.36 (1.09)	3.83 (0.79)
	post	3.67 (0.72)	3.98 (0.77)	3.42 (1.11)	3.89 (0.77)
	Statistic	50.5	13.5	15.0	25.5
	<i>p</i>	0.008 ^{*a}	0.064	0.027	0.029
Outcome expectations	pre	3.48 (0.94)	3.65 (1.07)	3.43 (1.22)	3.78 (0.88)
	post	3.49 (0.95)	3.63 (1.02)	3.59 (1.02)	3.78 (0.94)
	Statistic	10.00	3.50	34.50	17.50
	<i>p</i>	0.286	0.771	0.011 ^{*b}	0.558
Interests	pre	3.32 (1.03)	3.95 (0.87)	3.41 (1.01)	3.50 (0.95)
	post	3.35 (0.99)	3.93 (0.88)	3.52 (0.99)	3.57 (0.90)
	Statistic	10.00	0.00	57.5	22.0
	<i>p</i>	0.044	0.977	0.016	0.099
contextual supports	pre	3.09 (1.05)	3.50 (0.98)	3.41 (0.99)	3.27 (0.96)
	post	3.14 (1.02)	3.61 (0.89)	3.48 (0.92)	3.32 (0.91)
	Statistic	21.0	64.0	24.5	30.0
	<i>p</i>	0.016	0.003 ^{*c}	0.043	0.049
Personal inputs	pre	3.43 (1.32)	3.79 (1.13)	3.62 (1.25)	3.51 (1.21)
	post	3.51 (1.28)	3.82 (1.10)	3.68 (1.19)	3.55 (1.18)
	Statistic	10.00	11.00	17.0	5.00
	<i>p</i>	0.044	0.204	0.099	0.207

* Statistically significant; ^a: 74 pairs of values were tied; ^b: 75 pairs of values were tied; ^c: 73 pairs of values were tied.

References

- Hsu, Y.-S.; Fang, S.-C. Opportunities and Challenges of STEM Education. In *Asia-Pacific STEM Teaching Practices*; Springer Singapore: Singapore, 2019; pp. 1–16.
- OECD. *Education at a Glance 2021*; OECD: Paris, France, 2021; ISBN 9789264360778.
- UNESCO. *Cracking the Code Girls' and Women's Education in Science, Technology, Engineering and Mathematics (STEM)*; UNESCO: Paris, France, 2017; ISBN 9789231002335.
- National Center for Science and Engineering Statistics (NCSES). *Diversity and STEM: Women, Minorities, and Persons with Disabilities 2023*; NCSES: Alexandria, VA, USA, 2023.
- Wang, M.-T.; Degol, J.L. Gender Gap in Science, Technology, Engineering, and Mathematics (STEM): Current Knowledge, Implications for Practice, Policy, and Future Directions. *Educ. Psychol. Rev.* **2017**, *29*, 119–140. [[CrossRef](#)]
- Boiko, A.; Nistor, A.; Kudenko, I.; GrasVelazquez, A. *The Attractiveness of Science, Technology, Engineering and Mathematics Subjects. Results from Five Countries*; European Schoolnet: Brussels, Belgium, 2019.
- Marshman, E.M.; Kalender, Z.Y.; Nokes-Malach, T.; Schunn, C.; Singh, C. Female Students with A's Have Similar Physics Self-Efficacy as Male Students with C's in Introductory Courses: A Cause for Alarm? *Phys. Rev. Phys. Educ. Res.* **2018**, *14*, 020123-1–020123-17. [[CrossRef](#)]
- Master, A.; Meltzoff, A.N. Cultural Stereotypes and Sense of Belonging Contribute to Gender Gaps in STEM. *Int. J. Gen. Sci. Technol.* **2020**, *12*, 152–198.
- Lent, R.W.; Brown, S.D.; Hackett, G. Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance. *J. Vocat. Behav.* **1994**, *45*, 79–122. [[CrossRef](#)]
- Chachashvili-Bolotin, S.; Milner-Bolotin, M.; Lissitsa, S. Examination of Factors Predicting Secondary Students' Interest in Tertiary STEM Education. *Int. J. Sci. Educ.* **2016**, *38*, 366–390. [[CrossRef](#)]

11. Plasman, J.; Gottfried, M.; Williams, D.; Ippolito, M.; Owens, A. Parents' Occupations and Students' Success in STEM Fields: A Systematic Review and Narrative Synthesis. *Adolesc. Res. Rev.* **2021**, *6*, 33–44. [[CrossRef](#)]
12. Ardianto, D.; Rubini, B.; Pursitasari, I.D. Assessing STEM Career Interest among Secondary Students: A Rasch Model Measurement Analysis. *Eurasia J. Math. Sci. Technol. Educ.* **2023**, *19*, em2213. [[CrossRef](#)] [[PubMed](#)]
13. Ergün, A. Identification of the Interest of Turkish Middle-School Students in Stem Careers: Gender and Grade Level Differences. *J. Balt. Sci. Educ.* **2019**, *18*, 90–104. [[CrossRef](#)]
14. Staus, N.L.; Lesseig, K.; Lamb, R.; Falk, J.; Dierking, L. Validation of a Measure of STEM Interest for Adolescents. *Int. J. Sci. Math. Educ.* **2020**, *18*, 279–293. [[CrossRef](#)]
15. Kier, M.W.; Blanchard, M.R.; Osborne, J.W.; Albert, J.L. The Development of the STEM Career Interest Survey (STEM-CIS). *Res. Sci. Educ.* **2014**, *44*, 461–481. [[CrossRef](#)]
16. Bandura, A. Self-Efficacy: Toward a Unifying Theory of Behavioral Change. *Psychol. Rev.* **1977**, *84*, 191–215. [[CrossRef](#)] [[PubMed](#)]
17. Mau, W.-C.; Chen, S.-J.; Lin, C.-C. Assessing High School Student's STEM Career Interests Using a Social Cognitive Framework. *Educ. Sci.* **2019**, *9*, 151. [[CrossRef](#)]
18. Nariman, N.; Davis, J.N. Correlation of STEM Interest and Career Intent in High-School Students. In Proceedings of the IAFOR International Conference on Education, Official Conference Proceedings, Honolulu, HI, USA, 18 March 2021; pp. 163–181.
19. Mohd Shahali, E.H.; Halim, L.; Rasul, M.S.; Osman, K.; Mohamad Arsad, N. Students' Interest towards STEM: A Longitudinal Study. *Res. Sci. Technol. Educ.* **2019**, *37*, 71–89. [[CrossRef](#)]
20. Ugras, M. Determination of the Effects of Problem-Based STEM Activities on Certain Variables and the Views of the Students. *Int. Online J. Educ. Sci.* **2019**, *11*, 1–22. [[CrossRef](#)]
21. Baker, D. What Works: Using Curriculum and Pedagogy to Increase Girls' Interest and Participation in Science. *Theory Pract.* **2013**, *52*, 14–20. [[CrossRef](#)]
22. Heaverlo, C.A.; Cooper, R.; Lannan, F.S. STEM Development: Predictors for 6th–12th Grade Girls' Interest and Confidence in Science and Math. *J. Women Minor. Sci. Eng.* **2013**, *19*, 121–142. [[CrossRef](#)]
23. Cotabish, A.; Dailey, D.; Robinson, A.; Hughes, G. The Effects of a STEM Intervention on Elementary Students' Science Knowledge and Skills. *Sch. Sci. Math.* **2013**, *113*, 215–226. [[CrossRef](#)]
24. Akcay, B.; Akcay, H. Effectiveness of Science-Technology-Society (STS) Instruction on Student Understanding of the Nature of Science and Attitudes toward Science. *Int. J. Educ. Math. Sci. Technol.* **2015**, *3*, 37–45. [[CrossRef](#)]
25. Hacieminoglu, E. Elementary School Students' Attitude toward Science and Related Variables. *Int. J. Environ. Sci. Educ.* **2016**, *11*, 35–52. [[CrossRef](#)]
26. Odom, A.L.; Bell, C.V. Associations of Middle School Student Science Achievement and Attitudes about Science with Student-Reported Frequency of Teacher Lecture Demonstrations and Student-Centered Learning. *Int. J. Environ. Sci. Educ.* **2015**, *10*, 87–97. [[CrossRef](#)]
27. So, W.W.M.; Chen, Y.; Chow, S.C.F. Primary School Students' Interests in STEM Careers: How Conceptions of STEM Professionals and Gender Moderation Influence. *Int. J. Technol. Des. Educ.* **2022**, *32*, 33–53. [[CrossRef](#)]
28. López-Banet, L.; Perales, F.-J.; Jimenez-Liso, M.R. STEAM Views from a Need: The Case of the Chewing Gum and PH Sensopill (*Miradas STEAM Desde La Necesidad: El Caso de La Sensopildora Chicles y PH*). *J. Study Educ. Dev.* **2021**, *44*, 909–941. [[CrossRef](#)]
29. Grangeat, M.; Harrison, C.; Dolin, J. Exploring Assessment in STEM Inquiry Learning Classrooms. *Int. J. Sci. Educ.* **2021**, *43*, 345–361. [[CrossRef](#)]
30. Pedaste, M.; Mäeots, M.; Siiman, L.A.; de Jong, T.; van Riesen, S.A.N.; Kamp, E.T.; Manoli, C.C.; Zacharia, Z.C.; Tsourlidaki, E. Phases of Inquiry-Based Learning: Definitions and the Inquiry Cycle. *Educ. Res. Rev.* **2015**, *14*, 47–61. [[CrossRef](#)]
31. de Jong, T. Moving towards Engaged Learning in STEM Domains; There Is No Simple Answer, but Clearly a Road Ahead. *J. Comput. Assist. Learn.* **2019**, *35*, 153–167. [[CrossRef](#)]
32. Bybee, R.W. GUEST Editorial: Using the BSCS 5E Instructional Model to Introduce STEM Disciplines. *Sci. Child.* **2019**, *56*, 8–12. [[CrossRef](#)]
33. Bybee, R.W. Advancing STEM Education: A 2020 Vision. *Technol. Eng. Teach.* **2010**, *70*, 30–35.
34. Bybee, R.W.; Taylor, J.; Gardner, A.; Scotter, P.; Powell, J.; Westbrook, A.; Landes, N. *The BSCS 5E Instructional Model: Origins and Effectiveness*; NSTA: Richmond, VA, USA, 2006.
35. Nugent, G.; Barker, B.; Welch, G.; Grandgenett, N.; Wu, C.R.; Nelson, C. A Model of Factors Contributing to STEM Learning and Career Orientation. *Int. J. Sci. Educ.* **2015**, *37*, 1067–1088. [[CrossRef](#)]
36. Sakellariou, C.; Fang, Z. Self-Efficacy and Interest in STEM Subjects as Predictors of the STEM Gender Gap in the US: The Role of Unobserved Heterogeneity. *Int. J. Educ. Res.* **2021**, *109*, 101821. [[CrossRef](#)]
37. Wang, H.-H.; Lin, H.; Chen, Y.-C.; Pan, Y.-T.; Hong, Z.-R. Modelling Relationships among Students' Inquiry-Related Learning Activities, Enjoyment of Learning, and Their Intended Choice of a Future STEM Career. *Int. J. Sci. Educ.* **2021**, *43*, 157–178. [[CrossRef](#)]
38. Gkagkas, V.; Hatzikraniotis, E. On the Effect of Inquiry-Based Learning Activities on Students' Attitudes toward Science. *Iris J. Educ. Res.* **2024**, *4*. [[CrossRef](#)]
39. McDonough, E.; Sawyer, K.S.; Wilks, J.; Jacque, B. Students Attitudes Surrounding STEM: A Social Cognitive Career Theory Instrument for High School. *bioRxiv* **2021**. [[CrossRef](#)]

40. Tyler-Wood, T.; Knezek, G.; Christensen, R. Instruments for Assessing Interest in STEM Content and Careers. *J. Technol. Teach. Educ.* **2010**, *18*, 341–363.
41. Christensen, R.; Knezek, G. Relationship of Middle School Student STEM Interest to Career Intent. *J. Educ. Sci.* **2017**, *3*, 1–13. [[CrossRef](#)]
42. Playton, S.C.; Childers, G.M.; Hite, R.L. Measuring STEM Career Awareness and Interest in Middle Childhood STEM Learners: Validation of the STEM Future-Career Interest Survey (STEM Future-CIS). *Res. Sci. Educ.* **2024**, *54*, 167–184. [[CrossRef](#)]
43. Lent, R.W.; Brown, S.D.; Hackett, G. Contextual Supports and Barriers to Career Choice: A Social Cognitive Analysis. *J. Couns. Psychol.* **2000**, *47*, 36–49. [[CrossRef](#)]
44. Stewart, J.; Henderson, R.; Michaluk, L.; Deshler, J.; Fuller, E.; Rambo-Hernandez, K. Using the Social Cognitive Theory Framework to Chart Gender Differences in the Developmental Trajectory of STEM Self-Efficacy in Science and Engineering Students. *J. Sci. Educ. Technol.* **2020**, *29*, 758–773. [[CrossRef](#)]
45. Huang, C. Gender Differences in Academic Self-Efficacy: A Meta-Analysis. *Eur. J. Psychol. Educ.* **2013**, *28*, 1–35. [[CrossRef](#)]
46. Hardin, E.E.; Longhurst, M.O. Understanding the Gender Gap: Social Cognitive Changes during an Introductory Stem Course. *J. Couns. Psychol.* **2016**, *63*, 233–239. [[CrossRef](#)]
47. Altoum, R.M. Relationship between Attending STEM Extracurricular Programs and Aspiration toward STEM Careers. Doctoral Thesis, Walden University, Minneapolis, MN, USA, 2021.
48. Donmez, I. Impact of Out-of-School STEM Activities on STEM Career Choices of Female Students. *Eurasian J. Educ. Res.* **2021**, *91*, 173–203. [[CrossRef](#)]
49. Ogegbo, A.A.; Aina, A.Y. Exploring Young Students' Attitude towards Coding and Its Relationship with STEM Career Interest. *Educ. Inf. Technol.* **2024**, *29*, 9041–9059. [[CrossRef](#)]
50. Roncoroni, J.; Hernandez-Julian, R.; Hendrix, T.; Whitaker, S.W. Breaking Barriers: Evaluating a Pilot STEM Intervention for Latinx Children of Spanish-Speaking Families. *J. Sci. Educ. Technol.* **2021**, *30*, 719–731. [[CrossRef](#)]
51. Zeldin, A.L.; Britner, S.L.; Pajares, F. A Comparative Study of the Self-efficacy Beliefs of Successful Men and Women in Mathematics, Science, and Technology Careers. *J. Res. Sci. Teach.* **2008**, *45*, 1036–1058. [[CrossRef](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.