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Examination of teachers' self-effectiveness toward teaching integrated science, technology, reading, engineering, art, and mathematics: A cross-sectional study

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Abstract

This cross-sectional study examines teachers' self-reported effectiveness in teaching integrated science, technology, reading, engineering, art, and mathematics (STREAM) in high school education in the Kingdom of Saudi Arabia (KSA), based on a survey of 182 teachers. The respondents included male and female teachers of biology, mathematics, physics, chemistry, and earth sciences in high schools in the KSA. All teachers rated themselves highly in the categories of self-efficacy and enjoyment, which had the strongest correlation with each other among all the studied variables. Teachers' self-efficacy was found to have a more positive impact on enjoyment, including high feelings of enthusiasm, than on actual competence. Most of the respondents found it difficult to develop the new domains of STREAM, such as the reading and writing skills employed in science classes. It is essential for teachers in the KSA to increase their confidence and awareness of the positive effects of STREAM education on students.

Keywords: teacher self-effectiveness, 21st century skills, integrated STREAM, reading skills

INTRODUCTION

The science, technology, engineering, and mathematics (STEM) curriculum integrates four disciplines–science, technology, engineering, and mathematics–with the goal of developing critical thinking, creativity, collaboration, and adaptability. It equips students to address complex global challenges by fostering analytical and problem-solving skills. The science, technology, engineering, art, and mathematics (STEAM) curriculum builds upon STEM by adding Art, recognizing the value of creative thinking and visual learning in enhancing STEM skills. Art and design promote creativity, innovation, and the ability to think beyond traditional frameworks, making learning more engaging and inclusive, especially for visual learners. The science, technology, reading, engineering, arts, and mathematics (STREAM) curriculum further extends STEAM by incorporating Reading and literacy. This addition emphasizes reading comprehension and communication skills, which are essential for critical analysis and articulating ideas effectively. STREAM aims to prepare students for the demands of the 21st century, where interdisciplinary literacy and technological fluency are essential for navigating the complexities of the digital age. In an era shaped by advanced technologies, such as the Internet, these curricula address the evolving skills required for success, emphasizing adaptability, interdisciplinary learning, and the integration of creativity and communication (Alhomairi, 2018; Alzahrani, 2020; Perales & Aróstegui, 2024; Skowronek et al., 2022).

Many recent studies emphasize the importance of STEM and STEAM which is a multi-disciplinary approach that enhances students' learning potential by connecting STEAM to real-life experiences in providing students with an advantage and a competitive edge in the world marketplace. As a result, there has been a consistent global movement toward educational paradigms that focus on STEM and STEAM in order to enable students to be critical thinkers and problem solvers when addressing the obstacles faced by modern communities (Alhomairi, 2018; Alrasheedy, 2019; Alzahrani, 2020; Skowronek et al., 2022).

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Contribution to the literature

- The study makes a notable contribution to knowledge, because little research exists about teachers' self-effectiveness toward teaching integrated science, technology, reading, engineering, art, and mathematics (STREAM).
- The study argues that no significant differences between Saudi male and female teachers in the four subscales (i.e., difficulty and anxiety, teaching self-efficacy, utilitarianism, and enjoyment) and the total score of the scale.

In real-life learning, integrating subjects like science and art fosters a holistic approach, reflecting the interconnectedness of knowledge. The concept of integration emphasizes that learning outcomes are achieved through diverse methods and processes, shaped by the rapidly evolving technological, political, and social landscape.

The further addition of reading to form a STREAM paradigm has been suggested to help students' comprehension by enabling them to dig deeper into words and capture the significant points in text (Ardhian et al., 2020). As Ardhian et al. (2020) put it, "the ability to read is very complex and not only the ability to read it but also the ability to understand and interpret the contents of reading" (p. 109).

Current research argues that there is a lack of critical relevant direction in the science curriculum, which may be seen as being due to an absence of STREAM from the classroom learning environment. According to Alzahrani (2020), "this traditional science curriculum reveals and often amplifies the gap between the skills students acquire and the necessities of life and the global market today" (p. 1). For this reason, many students fail their science subjects in both high school and post-secondary education (Alhomairi, 2018).

Vital skills such as problem-solving, critical thinking, collaboration, and creativity, along with necessary technology competencies, are becoming increasingly indispensable as foundations of 21st century educational skills (Alhomairi, 2018; Alzahrani, 2020; Thibaut et al., 2018). It is worth noting that the Kingdom of Saudi Arabia (KSA) is still suffering from significant unemployment, despite its thriving educational context (Alrasheedy, 2019). Hence, graduating students in the KSA appear to lack relevant job-related skills.

The KSA has recently recognized the significance of STEM and STEAM in education (Alzahrani, 2020; Kayan-Fadlelmula et al., 2022). This research explores the challenges of traditional STEM and STEAM education as it relates to science teachers' current perception of educational practice. Teachers play a major role in shaping the incorporation of new subjects into a curriculum, as they have the greatest influence on whether a new approach is successfully implemented into practice (Pederson & West, 2017). According to Navarro et al. (2022), science teachers affect not only students' learning but also students' attitudes toward science and math, self-efficacy in these subjects, perceptions of gender stereotypes, and future decisions to undertake scientific careers. Darling-Hammond et al. (2020) argue that the central role of teachers in curriculum application should be taken into consideration, as it is teachers who determine the outcome of educational pursuits; the same applies to policy-makers in relation to the attitudes and perceptions of teachers.

Problem of Research

The increasing demand for a skilled workforce in the 21st century necessitates a comprehensive educational approach that integrates STREAM (Alhomairi, 2018; BouJaoude, 2020). Recently, several studies have highlighted the critical role of integrated STEM and STEAM disciplines in enhancing the essential cognitive skills, such as problem-solving, creativity, critical thinking, and inquiry, which are vital for developing professional leaders in their careers (BouJaoude, 2020).

However, the Saudi education system faces significant challenges, including outdated teaching methodologies, curriculum misalignments, and a lack of coherence with modern educational practices (Ardhian et al., 2020). These obstructions contribute to a disconnect between educational objectives and actual student performance, impeding the achievement of desired learning outcomes (Ardhian et al., 2020). The integration of reading into the existing STEAM–transforming it into a STREAM–addresses these gaps by enhancing comprehension and critical thinking skills. According to Ardhian et al. (2020), integrating reading comprehension is foundational to understand the meaning of comprehension by digging deeper into the words and capturing the significant points (Ardhian et al., 2020). "The ability to read is very complex and not only the ability to read it but also the ability to understand and interpret the contents of reading" (Ardhian et al., 2020, p. 109).

The fragmented approach to teaching science subjects in Saudi high schools–where mathematics, chemistry, biology, physics, and earth science are studied separately–has significantly contributed to poor student performance. According to Alzahrani (2020), this separation limits the opportunity for students to see connections between disciplines, hindering their overall understanding.

Consistent with study, results from the trends in international mathematics science study and the program for international student assessment showed a weak level of Saudi students' achievement mathematics, science, and reading of Saudi students in comparison with other countries (Albeladi, 2022). This pattern emphasizes the need for a more integrated educational approach that fosters deeper comprehension and application of knowledge across subjects.

The Saudi Arabia place strong emphasis on the educational sector, recognizing its s vital for economic stability, as reflected in financial reports and annual budget documents (Alfawaz et al., 2014). "Based on the financial reports and the annual budget reports for Saudi Arabia, it seems that education is the alternative priority for a stable economy" (Alfawaz et al., 2014, p. 25). Hence, the KSA has embarked Saudi National curriculum framework in order develop the educational system and improve the learning quality which aligned with the Saudi vision 2030 (Education and Training Evaluation Commission [ETEC], 2024). Despite being one of the largest labor markets globally, Saudi Arabia faces rising youth unemployment (Alfawaz et al., 2014), highlighting a critical disconnect between educational outcomes and workforce needs.

It is noted that the content of science curricula is focused on acquiring a great deal of knowledge and preserving it in a fragmented manner, which does not allow for integration with other aspects of other knowledge, leading to the emergence of educational outputs that are still centered on recall and memorization, and such knowledge are traditionally practiced in simple and repetitive experiments that students had previously seen. To address these issues, it is expected that the current curricula based on modern cognitive learning theories that promote the integration of subjects will achieve better results. Furthermore, aligning the curriculum with effective teaching strategies requires teachers apply an effective teaching methods to support students to become depends on having imagination and innovation skill such as problem-solving, critical thinking, inquiry, and creativity (Nuangchalerm et al., 2020).

A more holistic and interconnected curriculum, such as the STREAM approach, could positively increase the quality of learning objectives and promote the competences and abilities of all students, contributing to the development of 21st century skills. The integrated STEM and STEAM curriculum support students to become more socialized and focus on self-efficacy in their practical and academic opportunities. The development and application of this approach become clear through movements in many countries aimed to think of the STEAM approach rather than STEM approach, i.e., by adding arts to STEM. This shift addresses ongoing concerns about the effectiveness of science education, and the low participation of young people with science. By bridging the gap between school curricula and the real world, the STREAM approach empowers students and fosters deeper understanding and retention of the material (Subramaniam et al., 2023).

This cross-sectional study aims to investigate the influence of a broad range of background characteristics on teachers' self-reported effectiveness in teaching a STREAM curriculum. To do so, it examines teachers' self-reported effectiveness in integrating the STREAM disciplines into their teaching, based on a survey of teachers in the KSA. The following research questions are investigated:

1. What is the level of teachers self-reported effectiveness in teaching a STREAM curriculum?
2. Are there significant gender differences between male and female in teachers' self-reported effectiveness in teaching STREAM?
3. How do teachers' years of experience, academic level, and specialization in teaching science, combined STEM and STEAM, and combined STEM and STREAM affect their self-reported effectiveness in teaching a STREAM curriculum?

Literature Review

The STREAM concept is built on an earlier term, STEM. Cross-disciplinary STEM education focuses on STEM to "support science and technology, literate individuals, and high-level thinking skills" (Alzahrani, 2020, p. 38). Srikoom et al. (2017) conducted research on 154 in-service teachers from schools all throughout Thailand who taught both STEM- and non-STEM-related courses. A three-part questionnaire that included an open-ended question about general background knowledge and perceptions about STEM education and integration was used to gather information on teachers' perceptions. The research's findings indicated that 85.5% of the teachers who were subjected to the study had never heard of STEM education. About 19% of the in-service teachers were unable to define STEM education, whereas 20.53% believed that STEM was a transdisciplinary subject. The STEM-related and non-STEM in-service teachers both reported significant reservations regarding the engineering discipline within the STEM disciplines, despite the fact that the studied instructors found a STEM teaching method to be extremely fascinating.

Thibaut et al. (2018) employed a survey method to look at the impact of teachers' backgrounds and school-related factors on their attitudes for teaching STEM. The researchers took a unique method. To gain in-depth and nuanced understanding into the factors impacting teacher attitudes toward the five major STEM principles (integration, problem-centered, inquiry-based, design-based, and cooperative learning), these principles were explored separately. The outcomes of the multiple regression analyses demonstrated a positive relationship between professional development involvement and teachers' views toward all fundamental principles. Additionally, there was a favorable correlation between attitudes toward one or two principles and various teacher and school setting characteristics. Additionally, a negative association between numerous features of experience in mathematics and the overall number of years spent teaching

Alzahrani (2020) used a survey of science teachers and grade 11 and grade 12 students in the city of Jeddah, KSA, to investigate whether student gender and teachers' self-reported effectiveness affected students' interest in STEM. The study, which took constructivism as its theoretical foundation, was based on a quantitative survey study design with the *instrument for teachers' self-effectiveness toward teaching integrated STEM* and a modified version of the *student interest scale*. Constructivism is a foundational concept for STEM and has been shown to have a significant effect on student development, both socially and cognitively. The participants were male and female teachers of science, chemistry, physics, and mathematics, and male and female students enrolled in grade 11 and grade 12 in Jeddah, KSA. The results showed that female students had a greater interest in STEM than male students, while a weak positive correlation was found between teachers' self-reported effectiveness and students' interest in STEM.

A questionnaire was utilized by Vossen et al. (2021) to assess teachers' views regarding supervising research and design efforts in secondary schools. 130 teachers from the Netherlands who taught two relatively new STEM subjects–NLT, or "nature, life, and technology," and O&O, or "research and design," integrated STEM courses that are offered in a small number of Dutch schools and are project- and context-based–were included in the study. These integrated STEM topics have quite different student and teacher demographics. For example, NLT is taught to students in grades 10 through 12 by teachers who have degrees in science, whereas O&O is taught to students in grades 7 through 12 by any secondary school teacher. Teachers of O&O and NLT both had high self-efficacy scores on supervising, it was discovered.

Lv et al. (2021) used multiple-group structural equation modeling to conduct gender research of 798 grade 10 students in mainland China to compare the structural relationships between male and female student groups. In terms of STEM career expectations, STEM value beliefs, STEM self-efficacy beliefs, and STEM parental and teacher support, the results revealed that male students performed better than female students. Furthermore, parental support, STEM value beliefs, and STEM interest beliefs were found to predict the STEM career expectations of female students, whereas parental support, STEM self-efficacy, and STEM interest beliefs were found to positively influence the STEM career expectations of male students. In light of these findings, Lv et al. (2021) identified important gender variations in STEM career expectations, views, and support.

METHODOLOGY OF RESEARCH

Sample of Research

This study is based on a sample of 182 high school science teachers (i.e., teachers of biology, chemistry, physics, and earth sciences) in the KSA. This study utilized a purposive sampling to select participants based on specific characteristics. The purposive sampling was utilized to select two groups of participants in this study because the targeted participation was identified as science teacher's male and female for students in high school in some cities in Saudi Arabia a non-probability sampling method.

Surveys were originally sent to 150 male and 150 female teachers in the KSA. Of these, 182 responded, and their surveys are analyzed here. An Arabic version of the survey was sent to the respondents, who provided their informed consent for inclusion in this study. The survey introduction presented a summary of the study, including details on the participant agreement and a description of the study's purpose, benefits, probability of risk, "alternative procedure, and limit of confidentiality" (Johnson & Christensen, 2014, p. 202).

The New Version of the Teachers' Self-Effectiveness Toward Teaching Integrated STREAM Instrument

The teachers' self-effectiveness toward teaching integrated STREAM instrument was partially utilized in this study due to its highly relevant connection to constructivism, particularly in terms of teacher self-reported effectiveness and its focus on teachers' support for high school learning activities (Alzahrani, 2020; Vygotsky, 1978). Originally, the primary data source of this survey utilized by the Research Institute for Work and Society, called development and validation of an *instrument for measuring teachers' attitudes toward teaching integrated STEM.* The instrument, which was designed by Thibaut et al. (2018), can be used as "an attitude scale." This teacher survey was originally created in English; it was then translated into Arabic to be clear and understandable for Saudi teachers.

The first section of the survey includes demographic questions for teachers such as gender, location, university major, level of experience, level of education, and whether they have experience in STEM, STEAM, and/or STREAM. This section provides important and specific information on the sample and starts the survey with positive and non-threatening questions for the study's participants (Johnson & Christensen, 2014). The second section includes three main domains: cognition, 10 items; the affect, 10 items; and the perceived control, five items (Aldahmash et al., 2019). The cognition domain includes two scales: "perceived relevance," which contains five items; and "perceived difficulty," which contains five items. The affect domain has two scales: "anxiety," which includes five items; and "enjoyment," which also includes five items. The self-efficacy domain includes five items (Aldahmash et al., 2019). Two sections were added onto the end of the survey to cover the subjects of reading and the arts, to ensure that the survey was appropriate for the current quantitative study. Each section of the survey was developed based on its association with the four subcomponents related to the integration of STREAM content, namely: problem-solving, inquiry learning, critical thinking, and cooperation.

Data Analysis

The data was analyzed in terms of how it related to the research questions. We then described the central tendency of the data collection for each variable; that is, we used the means to report the average score of the survey respondents. In this study, the mean score was calculated and the percentage for each of the axis items of teacher surveys and it used the symbol of the mean (M) when reporting the average of these variables. Inferential statistics were used to analyze the data in this study.

Our aim with the inferential statistics was to examine the effect of gender on the surveyed teachers' self-reported effectiveness in STREAM, and to measure the relationship between teachers' self-reported effectiveness in STREAM and their gender, level of teaching experience, academic level, and level of experience in STEM, STEAM, or STREAM. The alpha level was used to determine whether there was a significant difference or relationship among variables. An alpha value (a) of .05 (level of significance) was applied for each statistical analysis in this study.

To address research question 1, a t-test was used to determine whether there was a significant difference in the reported mean of the effect of gender (male vs. female) on the science teachers' self-reported effectiveness. To address research question 2, a regression analysis was used to identify the impact of gender, teaching experience, academic level, and STEM, STEAM, and/or STREAM experience on the science teachers' self-reported effectiveness (continuous dependent). We then categorized the results to describe the findings.

Validity

An exploratory factor analysis (EFA) was performed using SPSS version 26 on the scores of 182 high school teachers in a survey conducted in the KSA. Before performing the EFA, the prerequisite assumptions were checked. The Kaiser-Meyer-Olkin (KMO) statistic was

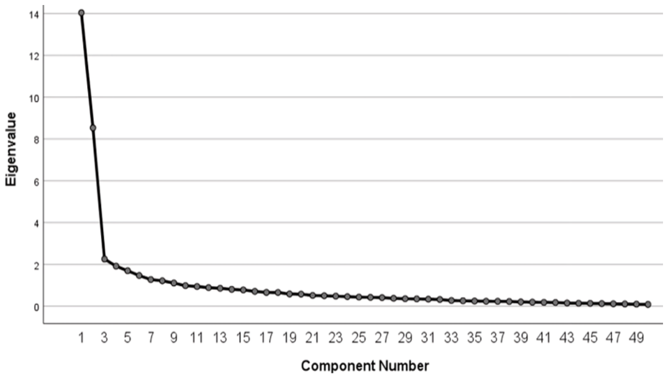

Figure 1. PCA scree plot (N = 182) (Source: Authors' own elaboration)

higher than .50, as suggested by Watkins (2018). The KMO measure of sampling adequacy was .881, and Bartlett's test of sphericity was approximately Chi-square 6,325.25 (df = 1,225, p value < 0.01).

An EFA with principal components was conducted to identify a robust factor structure of 50 scale items. In the first version of the scale, more than nine items were intended to represent each subscale. A ProMax rotation was used to spin the obtained factors into a straightforward structure. The following criteria were used to determine the number of factors to be retained:

(a) Kaiser's rule of retaining factors with eigenvalues greater than 1,

(b) the requirement that each factor have at least five items, and

(c) the requirement that each factor explain at least 10% of the total variance extracted (Khalaf, 2014).

The inclusion criterion for items in retained factors was that they had loadings of at least .30 on that factor (Khalaf, 2016a, 2016b). The analysis yielded four factors: factor 1 (difficulties and anxiety), factor 2 (teaching self-efficacy), factor 3 (utilitarianism), and factor 4 (enjoyment). Only one item did not meet the criteria and was omitted. The distribution of the items on the four extracted factors are presented.

Figure 1 shows the number of factors extracted from the survey data using principal component analysis (PCA). Four factors have eigenvalues greater than 1, namely, difficulty and anxiety, teaching self-efficacy, utilitarianism, and enjoyment.

As shown in **Table 1**, item 12 did not load to any of the factors; thus, this item was deleted from the subsequent analysis. When we scrutinized the statement for item 12, we found that it revolves around students rather than teachers, so it was logical for it to be irrelevant to the scale. The final version of the scale consisted of 49 items measuring the four dimensions of STEAM teaching effectiveness.

Table 1. Distribution of items on the four distinct factors (N = 182)

Factors	Loaded items	Number of items
Factor 1. Difficulties and anxiety	27, 30, 28, 26, 24, 29, 8, 9, 7, 6, 23, 3, 5, 10, 25, 4, 21, & 22	18
Factor 2. Teaching self-efficacy	50, 38, 48, 45, 40, 43, 33, 1, 2, 37, 35, 36, & 19	13
Factor 3. Utilitarianism	13, 15, 14, 19, 18, 20, 17, 11, 16, & 39	10
Factor 4. Enjoyment	41, 31, 42, 34, 46, 32, 44, & 47	8

Table 2. Cronbach's alpha and McDonald's omega coefficients (N = 182)

Subscale	Coefficient	Reliability	SE	Lower 90% CI	Higher 90% CI
Difficulties and anxiety	Omega	.952	.007	.935	.963
	Alpha	.952	.006	.937	.962
Teaching self-efficacy	Omega	.836	.024	.793	.884
	Alpha	.859	.020	.813	.890
Utilitarianism	Omega	.865	.017	.826	.894
	Alpha	.867	.016	.832	.894
Enjoyment	Omega	.834	.026	.770	.876
	Alpha	.841	.024	.786	.879
Total score	Omega	.824	.043	.740	.901
	Alpha	.896	.022	.841	.925

Table 3. Item-total correlations (N = 182)

Factor 1		Factor 2		Factor 3		Factor 4	
Item	C**	Item	C	Item	C	Item	C
27.	.482	50.	.341	13.	.206	41.	.361
30.	.561	38.	.385	15.	.283	31.	.440
28.	.477	48.	.308	14.	.297	42.	.353
26.	.496	45.	.285	19.	.313	34.	.434
24.	.507	40.	.368	18.	.333	46.	.269
29.	.461	43.	.300	20.	.187*	32.	.449
8.	.549	33.	.434	17.	.268	44.	.291
9.	.494	1.	.437	11.	.313	47.	.245
7.	.522	2.	.490	16.	.278		
6.	.512	37.	.506	39.	.422		
23.	.437	35.	.419				
3.	.530	36.	.469				
5.	.516	49.	.265				
10.	.494						
25.	.455						
4.	.499						
21.	.472						
22.	.475						

Note. C: Correlation & **Values are significant at the 0.01 level

Table 4. EFA (N = 182)

Item	Loadings				h2
	Factor 1	Factor 2	Factor 3	Factor 4	
27.	.828				.712
30.	.827				.668
28.	.814				.682
26.	.809				..649
24.	.807				.654
29.	.801				.683
8.	.766				.633
9.	.766				.582
7.	.756				.556
6.	.752				.551
23.	.742				.586
3.	.739				.583
5.	.716				.516
10.	.699			.370	.608
25.	.697				.478
4.	.670				.511
21.	.661				.542
22.	.642	.355		-..330	.562
50.		.655			.553
38.		.640			.508
48.		.593			.544
45.		.544			.431
40.		.542	0.450		.573
43.		.542			.426
33.		.540			.538
1.	.452	.521	-.357		.495
2.	.499	.518	-.322		.520
37.		.518		.317	.506
35.		.505			.480
36.		.504			.587
49.		.434			.494
13.			.860		.682
15.			.704		.553
14.			.702		.597
19.			.598		.454
18.			.573		.485
20.		.302	.488		.432
17.			.436		.445
11.			.418		.311

Reliability

Cronbach's alpha and McDonald's omega were both used to verify the reliability of the scale, as recommended by Khalaf and Abulela (2021) and Khalaf and Al-Said (2021). The reliability coefficients, standard errors, and 90% confidence intervals (CI) are reported in **Table 2**. **Table 2** shows that the values for internal consistency and reliability are high for the four subscales. It is clear that the standard errors are low and the spaces between the CIs are not wide.

Table 3 shows that the values of the item-total correlations are significant at the 0.01 level.

As shown in **Table 4**, the accumulative variance explained is larger than 50%, which is an acceptable value in social and educational science. This finding is consistent with the values indicated by Lambie et al. (2018).

Table 4 (Continued). EFA (N = 182)

Item	Loadings				h2
	Factor 1	Factor 2	Factor 3	Factor 4	
16.			.390	.386	.446
39.		.369	.370		.463
12.					.341
41.				.847	.341
31.				.676	.495
42.				.628	.483
34.				.510	.505
46.		.436		.468	.595
32.				.438	.461
44.		.302		.402	.437
47.		.304		.353	.473
Eigenvalue	14.038	8.533	2.254	1.914	
% of variance	28.075	17.066	4.507	3.829	
Cumulative %	28.075	45.141	49.648	53.477	

Note. h2: Communalities

RESULTS OF RESEARCH

Question 1. What Is the Level of Teachers' Self-Reported Effectiveness in Teaching a STREAM Curriculum?

To answer research question 1, the means, standard deviations, frequencies, and percentages were determined. **Table 5** shows the means and standard deviations of the items in the four subscales.

As shown in **Table 5**, the mean scores for Factor 3 are the highest among the factors.

Table 6 shows the frequencies and percentages of the agreement, neutral, and disagreement responses for the two scales of "anxiety" and "perceived difficulty."

As shown in **Table 6**, more than half of the respondents disagreed with the following statements: "I find it difficult to employ reading and writing skills in science classes and to be content with transferring scientific knowledge related to the subject" (60.4%); "I find it difficult to use reading in science teaching (i.e., text comprehension for understanding scientific terminology and theories" (57.7%); "I find it difficult to help students to increase their critical thinking, problem-solving, creativity, and innovation skills in science lessons" (55.5); "I find it stressful to enhance students' critical thinking skills during science lessons" (53.8); and "I find it stressful to use text comprehension (reading skills) while teaching science" (50.5%). However, 45.6% of the respondents agreed with the statement "I find it stressful to use complex tasks with multiple solutions."

Table 7 shows the frequencies and percentages of the respondents' agreement, neutral, and disagreement

Table 5. Means (M) and standard deviations (SD) of the scale items (N = 182)

Factor 1		Factor 2		Factor 3		Factor 4	
I	M (SD)	I	M (SD)	I	M (SD)	I	M (SD)
27.	2.84 (1.11)	50.	4.08 (.67)	13.	4.41 (.77)	41.	3.73 (.84)
30.	2.62 (1.13)	38.	4.05 (.70)	15.	4.26 (.73)	31.	3.76 (.80)
28.	2.75 (1.15)	48.	4.00 (.71)	14.	4.28 (.71)	42.	3.74 (.78)
26.	2.77 (1.12)	45.	3.93 (.78)	19.	4.15 (.70)	34.	3.90 (.86)
24.	2.99 (1.12)	40.	4.09 (.76)	18.	4.15 (.73)	46.	3.80 (.81)
29.	2.68 (1.13)	43.	4.00 (.74)	20.	4.14 (.81)	32.	3.70 (.81)
8.	2.52 (1.13)	33.	4.10 (.71)	17.	3.97 (.84)	44.	3.74 (.85)
9.	2.58 (1.12)	1.	3.31 (.91)	11.	4.30 (.79)	47.	3.78 (.85)
7.	2.87 (1.09)	2.	3.20 (1.0)	16.	3.92 (.99)		
6.	2.75 (1.17)	37.	3.99 (.84)	39.	4.14 (.77)		
23.	2.70 (1.10)	35.	4.07 (.81)				
3.	2.82 (1.21)	36.	4.00 (.83)				
5.	2.78 (1.16)	49.	3.98 (.76)				
10.	2.51 (1.21)						
25.	3.01 (1.15)						
4.	2.99 (1.01)						
21.	3.21 (0.98)						
22.	3.24 (0.97)						

Note. I: Item

Table 6. Frequencies and percentages of items in factor 1 (N = 182)

No	Items	A (%)	N (%)	D (%)
27.	I find it stressful to involve students in applying scientific concepts by making handicrafts or artworks.	57 (31.3)	43 (23.6)	82 (45.1)
30.	I find it stressful to apply writing and reading skills in science classes and to be content with transferring scientific knowledge related to the subject.	45 (24.7)	35 (19.2)	102 (56)
28.	I find it stressful to use text comprehension (reading skills) when teaching science.	51 (28.5)	38 (20.9)	92 (50.5)
26.	I find it stressful to integrate artworks, culture, and societal and cultural heritage into science teaching.	53 (29.1)	40 (22.0)	89 (48.9)
24.	I find it stressful to teach a class in which students are involved in design.	63 (34.6)	51 (28.0)	68 (37.4)
29.	I find it stressful to enhance students' critical thinking skills during science lessons.	51 (28.0)	33 (18.1)	98 (53.8)
8.	I find it difficult to use reading in science teaching (i.e., text comprehension for understanding scientific terminology and theories).	41 (22.5)	36 (19.8)	105 (57.7)
9.	I find it difficult to help students to increase their critical thinking, problem-solving, creativity, and innovation skills during science lessons.	43 (23.6)	38 (20.9)	101 (55.5)
7.	I find it difficult to involve students in applying scientific concepts to make handicrafts in class.	55 (30.2)	51 (28.0)	76 (41.8)
6.	I find it difficult to involve the arts while teaching science related to societal and cultural heritage.	49 (26.9)	51 (28.0)	82 (45.1)
23.	I find it stressful to teach a class in which students execute experiments.	52 (28.5)	34 (18.7)	96 (52.7)
3.	I find it difficult to teach a class in which students execute experiments.	60 (33.0)	35 (19.2)	87 (47.8)
5.	I find it difficult to ensure that all students are actively involved in group work.	56 (30.7)	36 (19.8)	90 (49.5)
10.	I find it difficult to employ reading and writing skills in science classes and to be content with transferring scientific knowledge related to the subject.	45 (24.7)	27 (14.8)	110 (60.4)
25.	I find it stressful to ensure that all students are actively involved in group work.	77 (42.3)	31 (17.0)	74 (40.7)
4.	I find it difficult to teach a class in which students are involved in engineering design.	60 (33.0)	57 (31.3)	55 (30.2)
21.	I find it stressful to align the content of my course with that of other STREAM courses.	67 (36.8)	76 (41.8)	39 (21.4)
22.	I find it stressful to use complex tasks with multiple solutions.	83 (45.6)	54 (29.7)	45 (24.7)

Note. A: Agree; N: Neutral; & D: Disagree

Table 7. Frequencies and percentages of items in factor 2 (N = 182)

No	Items	A (%)	N (%)	D (%)
50.	I feel capable of employing reading and writing skills in science.	152 (83.5)	28 (15.4)	2 (1.1)
38.	I find it stressful to apply writing and reading skills in science classes and only transfer scientific knowledge.	153 (84.1)	24 (13.2)	5 (2.7)
48.	I feel capable of training students to think critically when reading a scientific text.	148 (81.3)	30 (16.5)	4 (2.2)
45.	I feel capable of ensuring that all students are actively involved in group work.	140 (76.9)	35 (19.2)	7 (3.8)
40.	I like applying writing and reading skills to transfer scientific knowledge.	154 (84.6)	23 (12.6)	5 (2.7)
43.	I feel capable of teaching a lesson in which students execute experiments.	150 (82.4)	25 (13.7)	7 (3.8)
33.	I like teaching a class in which students execute experiments.	155 (85.2)	23 (12.6)	4 (2.2)
1.	I find it difficult to align science content with other STREAM-related disciplines.	26 (14.3)	88 (48.4)	26 (14.3)
2.	I find it difficult to use complex tasks with multiple solutions.	75 (41.2)	62 (4.1)	45 (24.7)
37.	I like involving students in applying scientific concepts to make handicrafts or artworks.	143 (78.6)	29 (15.9)	10 (5.5)
35.	I like ensuring that all students are actively involved in group work.	152 (83.5)	21 (11.5)	9 (4.9)
36.	I like integrating artworks into science teaching, such as scientific modeling and drawing.	146 (80.2)	24 (13.2)	12 (6.6)
49.	I feel capable of training students to think critically when reading a scientific text.	142 (78.0)	34 (18.7)	6 (3.3)

Note. A: Agree; N: Neutral; & D: Disagree

Table 8. Frequencies and percentages of items in factor 3 (N = 182)

No	Items	A (%)	N (%)	D (%)
13.	Students gain insight through experiences.	162 (89)	16 (8.8)	4 (2.2)
15.	Students acquire social skills by working in groups.	158 (86.8)	21 (11.5)	3 (1.6)
14.	Designing helps students to develop their reasoning skills.	159 (87.4)	21 (11.5)	2 (1.1)
19.	Students acquire critical thinking skills by employing reading comprehension skills to understand science content.	158 (86.8)	21 (11.5)	3 (1.6)
18.	There is great benefit in involving students in making handicrafts or artworks by applying scientific concepts.	156 (85.7)	22 (12.1)	4 (2.2)
20.	Employing reading skills to understand the sciences enhances students' perception of scientific concepts.	154 (84.6)	21 (11.5)	7 (3.8)
17.	Integrating artworks and handicrafts into teaching drives students' understanding of the science content.	142 (78.0)	28 (15.4)	12 (6.6)
11.	Linking technology, mathematics, and scientific concepts increases students' understanding.	157 (86.3)	20 (11.0)	5 (2.7)
16.	Integrating arts and culture into science teaching helps students understand natural laws.	131 (72.0)	36 (19.8)	15 (8.2)
39.	I like training students to think critically because it is challenging and fun when teaching science.	159 (87.3)	16 (8.8)	7 (3.8)

Note. A: Agree; N: Neutral; & D: Disagree

Table 9. Frequencies and percentages of items in factor 4 (N = 182)

No	Items	A (%)	N (%)	D (%)
41.	I feel capable of aligning the content of my course with that of other STREAM courses.	114 (62.6)	57 (31.3)	11 (6.0)
31.	I enjoy aligning the content of my course with that of other STERAM courses.	120 (65.9)	52 (28.6)	10 (5.5)
42.	I feel capable of using complex tasks with multiple solutions.	118 (64.9)	55 (30.2)	9 (4.9)
34.	I like teaching a class in which students are involved in design.	138 (75.8)	32 (17.6)	12 (6.6)
46.	I feel capable of integrating artworks, culture, and societal and cultural heritage into science teaching.	127 (69.7)	43 (23.6)	12 (6.6)
32.	I enjoy using complex tasks with multiple solutions.	121 (66.4)	46 (25.3)	15 (8.2)
44.	I feel capable of teaching a class in which students are involved in design.	123 (67.6)	44 (24.2)	15 (8.2)
47.	I feel capable of involving students in making handicrafts or artworks by applying scientific concepts.	123 (67.6)	48 (26.4)	11 (6.0)

Note. A: Agree; N: Neutral; & D: Disagree

responses for the three scales of "perceived difficulty," "enjoyment," and "self-efficacy."

As shown in **Table 7**, most of the respondents agreed with the following statements: "I like teaching a class in which students execute experiments" (85.2%); "I like applying writing and reading skills to transfer scientific knowledge" (84.6); and "I find it stressful to apply writing and reading skills in science classes and only transfer scientific knowledge" (84.1%). Only 26% agreed with the statement "I find it difficult to align science content with other STREAM-related disciplines."

Table 8 shows the frequencies and percentages of the agreement, neutral, and disagreement responses for the three scales of "perceived relevance" and "enjoyment."

As shown in **Table 8**, most of the respondents agree with the following statements: "students gain insight through experiences" (89%); "designing helps students to develop their reasoning skills" (87.4%); and "I like training students to think critically because it is challenging and fun when teaching science" (87.3%). Moreover, only 15% disagreed with the statement "integrating arts and culture into science teaching helps students understand natural laws."

Table 9 shows the frequencies and percentages of the agreement, neutral, and disagreement responses for the two scales of "self-efficacy" and "enjoyment."

As shown in **Table 9**, more than two-thirds of the respondents agreed with the statements "I like teaching a class in which students are involved in design" (75%) and "I feel capable of integrating artworks, culture, and societal and cultural heritage into science teaching" (69.7). Moreover, only 8.2% disagreed with the statements "I enjoy using complex tasks with multiple solutions" and "I feel capable of teaching a class in which students are involved in design."

Table 10. Male and female teachers' self-reported effectiveness in teaching STREAM

Subscales	Gender	N	Mean	SD	T	df	Sig.
Difficulty and anxiety	Male	119	51.55	14.67	1.149	180	.252
	Female	63	48.86	15.67			
Teaching self-efficacy	Male	119	50.83	6.18	-.505	180	.614
	Female	63	51.32	6.18			
Utilitarianism	Male	119	41.66	5.10	-.232	180	.816
	Female	63	41.86	5.75			
Enjoyment	Male	119	30.16	4.22	.091	180	.928
	Female	63	30.10	5.14			
Total score	Male	119	174.08	18.35	.774	180	.440
	Female	63	171.84	19.05			

Note. SD: Standard deviation & df: Degree of freedom

Table 11. Descriptive statistics for the survey respondents' experience

Experience in teaching		Number of people
Years teaching science	< 5 years	24
	5-10 years	33
	10-15 years	46
	15-20 years	30
	> 20 years	49
STEM, STEAM, or STREAM	No experience	120
	STEM experience	33
	STEM & STEAM experience	29

Table 12. Wilks' lambda results-1

Effect		Value	F	Hypothesis df	Error df	Sig.
Years teaching science	Wilks' lambda	.871	1.153	20.000	541.560	.291
STEM, STEAM, or STREAM		.926	1.271[b]	10.000	326.000	.245
Years teaching science × STEM, STEAM, or STREAM		.772	1.089	40.000	713.295	.329

Question 2. How Do Male and Female Teachers' Self-Reported Effectiveness in Teaching STREAM Differ?

To answer research question 2, a *t*-test for independent samples was used to detect the statistical differences between male and female teachers' self-reported effectiveness in STREAM. The findings are reported in **Table 10**.

As shown in **Table 10**, there are no statistically significant differences between male and female teachers in the four subscales (difficulty and anxiety, teaching self-efficacy, utilitarianism, enjoyment) and the total score of the scale. The t-test values are less than the significant limit.

Question 3. How Do Teachers' Years of Experience in Teaching Science, Combined STEM and STEAM, and Combined STEM and STREAM Affect Their Self-Reported Effectiveness in Teaching a STREAM Curriculum?

A two-way analysis of variance was performed to answer research question 3. **Table 11** shows the descriptive statistics for the survey respondents' experience.

Table 12 shows that the value of Wilks' lambda is not significant. Further, as shown in **Table 13**, no statistically significant differences were detected for Years teaching science; STEM, STEAM, or STREAM; or for the interaction between years teaching science and STEM, STEAM, or STREAM.

Table 13. Multivariate analysis of variance

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.
Years teaching science	Difficulty and anxiety	1,535.253	4	383.813	1.745	.143
	Teaching self-efficacy	137.001	4	34.250	.882	.476
	Utilitarianism	193.740	4	48.435	1.764	.138
	Enjoyment	51.267	4	12.817	.619	.649
	Total score	917.738	4	229.435	.659	.621
STEM, STEAM, or STREAM	Difficulty and anxiety	124.308	2	62.154	.283	.754
	Teaching self-efficacy	68.876	2	34.438	.887	.414
	Utilitarianism	32.753	2	16.377	.597	.552
	Enjoyment	21.209	2	10.604	.512	.600
	Total score	146.168	2	73.084	.210	.811

Table 13 (Continued). Multivariate analysis of variance

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.
Years teaching science × STEM, STEAM, or STREAM	Difficulty and anxiety	1,813.276	8	226.659	1.030	.415
	Teaching self-efficacy	185.080	8	23.135	.596	.780
	Utilitarianism	300.492	8	37.561	1.368	.214
	Enjoyment	178.407	8	22.301	1.078	.381
	Total score	3,903.121	8	487.890	1.401	.199
Error	Difficulty and anxiety	36 ,739.754	167	219.999		
	Teaching self-efficacy	6,484.195	167	38.828		
	Utilitarianism	4,584.596	167	27.453		
	Enjoyment	3,456.231	167	20.696		
	Total score	58,150.757	167	348.208		
Total	Difficulty and anxiety	507,188.000	182			
	Teaching self-efficacy	480,258.000	182			
	Utilitarianism	322,071.000	182			
	Enjoyment	169,039.000	182			
	Total score	5,528,900.000	182			

Question 4. How Do Teachers' Academic Level (i.e., Bachelor's or Master's Degree) and Specialization (i.e., Biology, Chemistry, Physics, or General Science) Affect Their Self-Reported Effectiveness in Teaching a STREAM Curriculum?

Table 14 provides descriptive statistics related to the education of the survey respondents to answer research question 4.

Table 15 provides the Wilks' lambda results. **Table 15** shows that the value of Wilks' lambda is not significant.

Further, as shown in **Table 16**, the analysis of variance shows that no statistically significant differences were detected for qualification, for specialization, or for the interaction between qualification and specialization.

Table 14. Descriptive statistics on the respondents of the survey

		N
Qualification	Bachelor's degree	163
	Master's degree	19
Specialization	Chemistry	53
	Physics	56
	Biology	62
	General science	11

DISCUSSION

The present research utilized the Saudi teachers' self-effectiveness toward teaching integrated STREAM survey item to find out how self-confident the teachers were. "perceived relevance," "perceived difficulty," "anxiety," "enjoyment," and "self-efficacy" were the five dimensions that comprised the survey. The most highly scored scale was teachers' perception of the survey's

Table 15. Wilks' lambda results-2

Effect		Value	F	Hypothesis df	Error df	Sig.
Qualification	Wilks' lambda	.965	1.243^{b}	5.000	171.000	.291
Specialization		.919	.974	15.000	472.457	.482
Qualification × specialization		.913	1.590^{b}	10.000	342.000	.108

Table 16. Multivariate analysis of variance of teachers' academic level and specialization

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.
Qualification	Difficulty and anxiety	355.141	1	355.141	1.577	.211
	Teaching self-efficacy	44.009	1	44.009	1.157	.284
	Utilitarianism	128.080	1	128.080	4.647	.032
	Enjoyment	20.045	1	20.045	.992	.321
	Total score	7.976	1	7.976	.024	.878
Specialization	Difficulty and anxiety	220.711	3	73.570	.327	.806
	Teaching self-efficacy	16.330	3	5.443	.143	.934
	Utilitarianism	91.905	3	30.635	1.112	.346
	Enjoyment	94.789	3	31.596	1.563	.200
	Total score	1,130.347	3	376.782	1.116	.344
Qualification × specialization	Difficulty and anxiety	454.047	2	227.023	1.008	.367
	Teaching self-efficacy	32.766	2	16.383	.431	.651
	Utilitarianism	11.346	2	5.673	.206	.814
	Enjoyment	7.643	2	3.822	.189	.828
	Total score	595.214	2	297.607	.882	.416

Table 16 (Continued). Multivariate analysis of variance of teachers' academic level and specialization

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.
Error	Difficulty and anxiety	39,410.669	175	225.204		
	Teaching self-efficacy	6,658.755	175	38.050		
	Utilitarianism	4,823.095	175	27.561		
	Enjoyment	3,537.464	175	20.214		
	Total score	59,075.551	175	337.575		
Total	Difficulty and anxiety	507,188.000	182			
	Teaching self-efficacy	480,258.000	182			
	Utilitarianism	322,071.000	182			
	Enjoyment	169,039.000	182			
	Total score	5,528,900.000	182			

relevance. "Students gain insight through experiences" and "integrating arts and culture into science teaching helps students to understand natural laws." are two assertions that most teachers believe are relevant to STREAM. Alzahrani (2020) found that nearly all Saudi teachers positively perceived the relevance of STEM education, which is consistent with our findings. The present findings showed that among the subcategories of supervising research and design activities, "self-efficacy" and "enjoyment" had the strongest connections, the teachers' high levels of self-efficacy might be attributed more to their passion than to their real skill, as research has demonstrated that there is only a minimal association between the teachers' attitudes and their actual knowledge (Schwarzer & Hallum, 2008).

The statements "I find it difficult to employ reading and writing skills in science classes and to be content with transferring scientific knowledge related to the subject" and "I find it difficult to use reading in science teaching (i.e., text comprehension for understanding scientific terminology and theories)" were found to be disagreed with by over half of the surveyed teachers. This result stands in contrast to what educators have said about their struggles to keep up with course material when they are teaching numerous classes at once (El-Deghaidy et al., 2017; Margot & Kettler, 2019; Quigley et al., 2017). Thus, STREAM education should incorporate the explicit integration of disciplines in a way that is both clear and purposeful for students (Margot & Kettler, 2019). Creating new STEM challenges that integrate different areas has allegedly been challenging for teachers. Margot and Kettler (2019) found that educators have also faced resistance when trying to incorporate STEM pedagogy into lessons that cover more traditional subject matter.

In the present study, the survey also showed that the majority of respondents had positive self-efficacy in relation to the statements "I like applying writing and reading skills to transfer scientific knowledge" and "I like teaching a class in which students execute experiments." In addition, in relation to the "enjoyment" scale, more than two-thirds of the surveyed Saudi educators concurred that "I feel capable of integrating artworks, culture, and societal and cultural heritage into science teaching" and "I like teaching a class in which students are involved in design." According to the teachers, the inclusion of engineering in the mathematics and science curricula brings the curricula to life.

Teachers felt that their students were enthusiastic about STEM subjects. Understudies exhibited a largely predictable response during STEM education, according to the instructors. Furthermore, the teachers stated that the major reason for integrating STEM into their lessons was the consequent improvement in student interest and participation. Nadelson et al. (2013) found that when instructors are effective, they are more likely to embrace new curriculum and work with students and administrators to implement innovative teaching practices. Teachers who report high levels of self-efficacy may be more inclined to embrace and modify inquiry-based, student-centered, critical-thinking pedagogies (Alsulami, 2016).

The four subscales (i.e., difficulty and anxiety, teaching self-efficacy, utilitarianism, and enjoyment) and the overall scale score did not differ significantly between the male and female teachers. Relatively little research has been done on the relation between gender and self-efficacy, particularly in the KSA, where women and girls have historically been restricted to traditional roles and occupations (Al-ghamdi & Al-Salouli, 2013; El-Deghaidy et al., 2017). Since STEM is still largely perceived as a male generalized space (Lv et al., 2022; Makarova et al., 2019), there is a clear gender imbalance among researchers who have worked in STEM fields for a long time. Thus, it is crucial to identify the factors influencing gender differences in STEM career expectations among Saudi high school students in order to increase Saudi girls' propensity to major in STEM-related fields. According to Lv et al. (2021), students within the Saudi culture are likely to view STEM as a field with "masculine characteristics," making it difficult for Saudi women to adequately grow and self-identify in this field.

The present study found that the interaction between Years of teaching science and STEM, STEAM, or STREAM experience showed no significant differences. According to Margot and Kettler (2019), teachers' interest in and preparedness for teaching STEM are unaffected by their years of experience. Nadelson et al. (2013) found that teachers' positive attitudes toward engineering in the classroom increased with age. According to Park et al. (2016), secondary teachers are more skeptical than elementary teachers of the potential impact of STEM education on student achievement. Thus, the current finding aligns with the study by Park et al. (2016), in which only one-third of surveyed early childhood educators considered themselves to be prepared to teach STEM subjects. Teachers in middle schools (grades 6-grade 8) expressed concern regarding lesson planning, as they did not know how long students would need to complete each task. There is a lack of focus on STEM education in Saudi universities, particularly in the fields of mathematics and biology. Science instructors in elementary schools are experts in STEM education, not educators in STEM fields. Consequently, they face a formidable obstacle in their quest to comprehend the interconnections among the fields of science, innovation, design, and mathematics.

CONCLUSIONS

This cross-sectional study used a quantitative method to investigate teachers' self-reported effectiveness in teaching STREAM, based on a survey of 182 teachers in the KSA. The responses showed that the teachers' self-reported effectiveness was high in the four axes of perceived difficulty and anxiety, teaching self-efficacy, perceived relevance, and enjoyment. The highest-rated axis was teachers' perceived relevance (of teaching STREAM in the classroom).

In addition, we found that there were no statistically significant differences between male and female teachers in the four subscales (i.e., difficulty and anxiety, teaching self-efficacy, utilitarianism, and enjoyment) and the total score of the scale. We also found no statistically significant differences for Years of teaching science, STEM, STEAM or STREAM, and for the interaction between Years of teaching science with STEM, STEAM, or STREAM. Moreover, the results showed no statistically significant differences for qualification, specialization, and the interaction between qualifications and specialization.

These findings align with the work of Alzahrani (2020) who reported that most Saudi teachers perceived the relevance of teaching STEM very strongly. The present research observed that the categories self-efficacy and enjoyment had the highest correlation when we examined the data correlations between the subcategories of supervising research and design activities. Furthermore, our study found no significant differences between Saudi male and female teachers in the four subscales (i.e., difficulty and anxiety, teaching self-efficacy, utilitarianism, and enjoyment) and the total score of the scale. Surprisingly, we found that comparatively little research on this specific topic has been published, particularly in the context of Saudi Arabia, where girls and women have historically been limited to traditional roles and occupations (Al-ghamdi & Al-Salouli, 2013; El-Deghaidy et al., 2017). This might be because STEM is generally perceived as a male-stereotyped domain (Lv et al., 2022; Makarova et al., 2019) and the gender divide among researchers with extensive experience in STEM subjects is evident. To encourage more Saudi girls to choose STEM-related disciplines, it is essential to examine the gender variations in STEM career expectations among Saudi high school students and identify the variables that affect them.

This study has some limitations. Our sample size of 182 science teachers is relatively small compared with the total number of science teachers working in the KSA, although this limitation may be typical for quantitative studies. In addition, these results apply only to the context of the KSA, so their generalizability to other contexts cannot be assumed. As our viewpoint, our experience in conducting this study was constrained by the limitations of the survey questions employed. The teachers survey could have included more questions about their interest levels in pursuing a STEM career. Additionally, students may have a student questionnaire that could have inquired about other factors influencing student interest in STEM and STEAM such as prospective career opportunities. This study could have also inquired about teachers' interest in STEM, STEAM education and its role in innovation. This study was important to investigate the relationship between teachers and students, though students and teachers were not asked specifically about their interest levels in science, mathematics, and STEM curricula. This limitation provides an opportunity for future researchers to better understand how teachers' interest helps shape students' interest toward innovation and creativity.

Based on the findings of this study, several recommendations can be made for school administrators in the KSA. The first recommendation concerns the implementation of STREAM in the KSA. It is recommended that administrators improve classroom environments and increase educational facilities in order to better engage students in science classes and interest them in the topics being studied. According to Aldahmash et al. (2019), teachers' positive attitudes promote students' engagement in integrated STEM in the classroom. Thus, it is recommended that science teachers in the KSA be encouraged and supported in their important role of prompting their students to use critical thinking and understand new knowledge. Several studies have found that integrating STEM and STEAM education into the school curriculum encourages students to engage with science creatively and critically and helps direct students into future STEM- and STEAM-related professions (Alzahrani, 2020; El-Deghaidy et al., 2017; Skowronek et al., 2022). Hence, school administrators in the KSA are encouraged to commit a portion of their school budget to improving the integration of science with other disciplines (i.e., reading, engineering, the arts, and mathematics) and providing technology in the classroom (Alzahrani, 2020).

The second recommendation is for education administrators to engage science teachers in training development programs that can support teachers in building their teaching capacity to help students master 21st century STREAM skills.

Finally, while this study did not investigate teachers' opinions in qualitative terms or how teaching capacity can affect student achievement, these are essential areas for further research. It is recommended that the KSA Ministry of Education employ STREAM-education professional development programs to train teachers and provide crucial support for them, thereby enabling teachers to be more confident and effective in their teaching process and more interested in integrating STREAM into their teaching.

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REFERENCES

Albeladi, A. A. (2022). Assessing students' learning outcomes in the Saudi education system from the perspective of various stakeholders. *Journal of Educational and Social Research, 12*(3), 287-299. https://doi.org/10.36941/jesr-2022-0087

Aldahmash, A. H., Alamri, N. M., & Aljallal, M. A. (2019). Saudi Arabian science and mathematics teachers' attitudes toward integrating STEM in teaching before and after participating in a professional development program. *Cogent Education, 6*(1), Article 1580852. https://doi.org/10.1080/2331186X.2019.1580852

Alfawaz, A., Hilal, K., & Alghannam, Z. (2014). Would the educational programs help in solving Saudi Arabia's employment challenges? *International Journal of Academic Research in Economics and Management Sciences, 3*(1), 24.

Al-ghamdi, A. K. H., & Al-Salouli, M. S. (2013). Saudi elementary school science teachers' beliefs: Teaching science in the new millennium. *International Journal of Science and Mathematics Education, 11*(2), 501-525. https://doi.org/10.1007/s10763-012-9353-0

Alhomairi, A. O. (2018). A proposed perspective for developing science curriculum for the upper primary grades in accordance to Saudi Arabia's vision for 2030: An analytical and descriptive study according to the Delphi method. *International Journal of Higher Education, 7*(1), 69-86. https://doi.org/10.5430/ijhe.v7n1p69

Alrasheedy, A. (2019). The cost of unemployment in Saudi Arabia. *International Journal of Economics and Finance, 11*(11), 30-42. https://doi.org/10.5539/ijef.v11n11p30

Alsulami, S. (2016). Toward a constructivist approach in Saudi education. *English Language Teaching, 9*(12), 104-108. https://doi.org/10.5539/elt.v9n12p104

Alzahrani, E. M. (2020). *An examination of students' gender, teachers' self-reported effectiveness, and students' interest in science, technology, engineering, and mathematics (STEM) as mandated by Saudi Arabia's vision 2030* [Doctoral dissertation, Concordia University].

Ardhian, T., Ummah, I., Anafiah, S., &Rachmadtullah, R. (2020). Reading and critical thinking techniques on understanding reading skills for early grade students in elementary school. *International Journal of Instruction, 13*(2), 107-118. https://doi.org/10.29333/iji.2020.1328a

BouJaoude, S. (2020). STEM education in the Arab countries: Rationale, significance, and future prospects. In N. Mansour, & H. El-Deghaidy (Eds.), *STEM in science education and S in STEM* (pp. 213-241). Brill.

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science, 24*(2), 97-140. https://doi.org/10.1080/10888691.2018.1537791

El-Deghaidy, H., Mansour, N., Alzaghibi, M., & Alhammad, K. (2017). Context of STEM integration in schools: Views from in-service science teachers. *Eurasia Journal of Mathematics Science and Technology Education, 13*(6), 2459-2484. https://doi.org/10.12973/eurasia.2017.01235a

ETEC. (2024). National Center for Academic Accreditation and Evaluation. *The Education and Training Evaluation Commission*. https://www.etec.gov.sa/en/ncaaa

Johnson, B., & Christensen, L. (2014). *Educational research: Quantitative, qualitative, and mixed approaches* (5th ed.). SAGE.

Kayan-Fadlelmula, F., Sellami, A., Abdelkader, N., & Umer, S. (2022). A systematic review of STEM education research in the GCC countries: Trends, gaps and barriers. *International Journal of STEM Education, 9*, Article 2. https://doi.org/10.1186/s40594-021-00319-7

Khalaf, M. A. (2014). Validity and reliability of the academic resilience scale in the Egyptian context. *US-China Education Review B, 4*(3), 202-210.

Khalaf, M. A. (2016a). Confirmatory factor analysis of the English learning anxiety scale (ELLAS) in the Egyptian context. *International Educational E-Journal, 5*(2).

Khalaf, M. A. (2016b). The relationship between emotional intelligence and academic achievements in males and females in the Egyptian context. *Psychology Research, 6*(10), 567-578. https://doi.org/10.17265/2159-5542/2016.10.002

Khalaf, M. A., & Abulela, M. A. (2021). The academic buoyancy scale: Measurement invariance across culture and gender in Egyptian and Omani undergraduates. *European Journal of Educational Research, 10*(4), 2121-2131. https://doi.org/10.12973/eu-jer.10.4.2121

Khalaf, M. A., & Al-Said, T. T. (2021). The Egyptian validation study of the resilience scale for adults (RSA) and its utility in predicting depression. *The Open Psychology Journal, 14*, 83-92. https://doi.org/10.2174/1874350102114010083

Khoshaim, H. B. (2017). High school graduates' readiness for tertiary education in Saudi Arabia. *International Journal of Instruction, 10*(3), 179-194. https://doi.org/10.12973/iji.2017.10312a

Lambie, G. W., Mullen, P. R., Swank, J. M., & Blount, A. (2018). The counseling competencies scale: Validation and refinement. *Measurement and Evaluation in Counseling and Development, 51*(1), 1-15. https://doi.org/10.1080/07481756.2017.1358964

Lv, B., Wang, J., Zheng, Y., Peng, X., & Ping, X. (2022). Gender differences in high school students' STEM career expectations: An analysis based on multi-group structural equation model. *Journal of Research in Science Teaching, 59*(10), 1739-1764. https://doi.org/10.1002/tea.21772

Makarova, E., Aeschlimann, B., & Herzog, W. (2019). The gender gap in STEM fields: The impact of the gender stereotype of math and science on secondary students' career aspirations. *Frontiers in Education, 4*. https://doi.org/10.3389/feduc.2019.00060

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *International Journal of STEM Education, 6*, Article 2. https://doi.org/10.1186/s40594-018-0151-2

Nadelson, L. S., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for science teachers. *The Journal of Educational Research, 106*, 157-168. https://doi.org/10.1080/00220671.2012.667014

Navarro, M., Martin, A., & Gómez-Arízaga, M. P. (2022). Profiles of pre-service primary teachers: Attitudes, self-efficacy, and gender stereotypes in teaching science and mathematics. *Eurasia Journal of Mathematics, Science and Technology Education, 18*(1), Article em2062. https://doi.org/10.29333/ejmste/11483

Nuangchalerm, P., Prachagool, V., Prommaboon, T., Juhji, J., Imroatun, I., & Khaeroni, K. (2020). Views of primary Thai teachers toward STREAM education. *International Journal of Evaluation and Research in Education, 9*(4), 987-992. https://doi.org/10.11591/ijere.v9i4.20595

Park, H., Byun, S. Y., Sim, J., Han, H. S., & Baek, Y. S. (2016). Teachers' perceptions and practices of STEAM education in South Korea. *Eurasia Journal of Mathematics, Science and Technology Education, 12*(7), 1739-1753. https://doi.org/10.12973/eurasia.2016.1531a

Pederson, D. E., & West, R. R. (2017). High school STEM teachers' perceptions of the work environment. *Education, 138*(1), 89-103.

Perales, F. J., & Aróstegui, J. L. (2024). The STEAM approach: Implementation and educational, social and economic consequences. *Arts Education Policy Review, 125*(2), 59-67. https://doi.org/10.1080/10632913.2021.1974997

Quigley, C. F., Herro, D., & Jamil, F. M. (2017). Developing a conceptual model of STEAM teaching practices. *School Science and Mathematics, 117*(1-2), 1-12. https://doi.org/10.1111/ssm.12201

Schwarzer, R., & Hallum, S. (2008). Perceived teacher self-efficacy as a predictor of job stress and burnout: Mediation analyses. *Applied Psychology: An International Review, 57*, 152-171. https://doi.org/10.1111/j.1464-0597.2008.00359.x

Skowronek, M., Gilberti, R. M., Petro, M., Sancomb, C., Maddern, S., & Jankovic, J. (2022). Inclusive STEAM education in diverse disciplines of sustainable energy and AI. *Energy and AI, 7*, Article 100124. https://doi.org/10.1016/j.egyai.2021.100124

Srikoom, W., Hanuscin, D. L., & Faikhamta, C. (2017). Perceptions of in-service teachers toward teaching STEM in Thailand. *Asia-Pacific Forum on Science Learning and Teaching, 18*(2), Article 6.

Subramaniam, V., Karpudewan, M., & Roth, W. M. (2023). Unveiling the teachers' perceived self-efficacy to practice integrated STrEaM teaching. *The Asia-Pacific Education Researcher, 32*(3), 327-337. https://doi.org/10.1007/s40299-022-00655-4

Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., Boeve-de Pauw, J., Dehaene, W., Deprez, J., De Cock, M., Hellinckx, L., Knipprath, H., Langie, G., Struyven, K., Van de Velde, D., Van Petegem, P., & Depaepe, F. (2018). Integrated STEM education: A systematic review of instructional practices in secondary education. *European Journal of STEM Education, 3*(1), Article 02. https://doi.org/10.20897/ejsteme/85525

Vossen, T. E., Henze, I., Rippe, R. C. A., Van Driel, J. H., & De Vries, M. J. (2021). Attitudes of secondary school STEM teachers towards supervising research and design activities. *Research in Science Education, 51*(2), 891-911. https://doi.org/10.1007/s11165-019-9840-1

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Watkins, M. W. (2018). Exploratory factor analysis: A guide to best practice. *Journal of Black Psychology, 44*(3), 219-246. https://doi.org/10.1177/0095798418771807