Mathematics Teachers' Perceptions the Steam Approach: Science, Technology, Engineering, Arts, and Mathematics and Its Relationship with Some Variables

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Abstract

This paper aimed to investigate the perceptions of mathematics teachers in Saudi Arabia regarding the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach. A sample of 350 teachers from the Eastern Province completed a 40-item survey on their STEAM perceptions and teaching requirements. Descriptive and inferential statistical analyses revealed overall positive perspectives, with 78.6% strongly agreeing that STEAM transforms classrooms into creative environments. However, just 58.4% felt it enabled active learning, and 67.4% were unsure about systemic support. Significant differences emerged based on teacher gender and qualifications, but not experience levels or stages. While largely optimistic attitudes exist toward STEAM's value, persistent resourcing, competency, and policy barriers likely impede classroom adoption. Recommendations encompass boosting investments in STEAM infrastructure, aligned teacher professional development, specialized materials and tools, and integration support across subjects. Further research incorporating mixed methods, expanded samples, and longitudinal tracking can delineate evidence-based strategies to catalyze effective STEAM adoption. The study recommended enhancing the effectiveness of the STEAM approach in education, especially in mathematics.

Keywords: perceptions, STEAM, technology, engineering, mathematics

1. Introduction

Our current era witnesses significant technological and cognitive advancements, along with rapid changes in all aspects of life. These transformations have imposed substantial challenges on educational systems, compelling them to keep pace. Consequently, there is an urgent need to explore modern teaching approaches that aid students in developing various thinking skills and enhancing their practices in inquiry and analysis. This is crucial for preparing a generation equipped with 21st-century skills to meet the demands of the job market.

In order to achieve goals that lead to the holistic growth of learners' personalities, educators strive to employ modern educational theories and teaching methods. In this dynamic environment, it is essential for educational development to have qualified teachers who possess fundamental knowledge for achieving excellence and success in the educational process. Therefore, it becomes imperative to enhance teachers' professional performance and motivate them to use modern teaching approaches aimed at developing students' capabilities and imparting the necessary knowledge and skills for life in the face of rapid change.

As a result of this trend, different approaches to education have emerged, focusing on combining subjects, connecting theory with practice to meet people's needs, and using scientific and informational factors to improve social, economic, and educational systems.

Some countries are working on developing and fostering research in education, where the public and private sectors collaborate to implement programs related to science and technology, develop research, and improve the educational process with the aim of achieving economic growth, improving individual living standards, and advancing in the fields of safety and health. One of these programs is the STEM education program (National Academy of Science, 2014), which considers science, technology, engineering, and mathematics as an integrated multidisciplinary approach, drawing the attention of international organizations seeking to develop their human resources in specialized fields that support innovation and competitiveness. Hence, the National Governors Association (NGA) emphasizes the necessity of enhancing the efficiency of teachers in STEM fields and increasing the number of students pursuing relevant advanced studies (Song et al., 2016).

The integrative approach philosophy, which involves the integration of mathematics and other sciences in their context, traces back to the theory that effective learning builds upon sensory experience in the world. The learner responds to these experiences by developing their cognitive structure (Berlin & Kyungpook, 2005). When examining mathematics and science, it becomes evident that they are two sides of the same coin, inseparable from each other. Science supports mathematical concepts and relationships, while mathematics provides the tools and language for analyzing scientific concepts. Furthermore, mathematics makes a significant contribution to the development of science and technology. The idea of integrating mathematics and science has materialized in development projects adopted by educational institutions, among the most notable being the School Science and Mathematics Association (SSMA) in the United States (Faqihi, 2019, p. 24).

Many educators believe that transitioning from STEM to STEAM offers numerous educational benefits. Sousa and Pilecki (2013) argue that art and science share similar tasks. David contends that integrating the arts into other sciences is vital, as it cultivates scientific curiosity, enhances detailed observation, allows for different visualizations of objects, and fosters innovation and creativity. According to Hassan (2020), the transition to STEAM is not simply adding arts to the STEM approach, but rather developing high-level design and engineering skills while providing students with opportunities to innovate and invent according to their circumstances. This approach requires students to create original works using STEM, allowing them to choose how and what they produce, making a significant and substantial difference.

Cevik (2018) suggests that integrating the arts into the STEM curriculum not only increases academic achievements in science, technology, engineering, and mathematics but also enhances students' artistic abilities. The study recommended that the STEAM approach should become a fundamental model in education, fostering creative and artistic learning in science through the integration of the arts, especially since the evolution of engineering jobs has increasingly emphasized the artistic quality of products.

Hilary (2017) and Al-Souht (2020) concur that the STEAM approach, a modern methodology for teaching various subjects, offers several general benefits. These benefits include highlighting the interactive relationships between STEAM disciplines to develop a deep understanding of scientific concepts, enhancing 21st-century skills among students, fostering higher-order thinking skills, creativity, innovation, and life skills, and connecting the curriculum to society and daily life.

Both Ghanem (2017) and Al-Salahi (2019) highlight that the STEM approach focuses on integrated conceptual understanding, problem-solving, and scientific, creative, and critical thinking. It entails integrating scientific content and thinking skills into a variety of specializations, emphasizing self-directed experiential learning, laboratory research in pairs, and the intensive application of scientific activities. The STEAM approach builds on this by creating an educational environment where students can engage in workshops in science, technology, engineering, arts, and mathematics beyond traditional classroom instruction. This approach aims to build students' confidence, self-reliance, and sense of accomplishment. It encourages them to value their ideas and approaches to problem-solving by addressing the difficulties they encounter in understanding and comprehending subjects. The goal is to enable learners to engage in scientific practices and apply comprehensive, interconnected concepts to deepen their understanding of key ideas in these areas (Grandin, 2016, p. 37).

Teachers play a crucial role in teaching STEAM. Edward Locke (2009, p. 28) underscored the significance of inspiring teachers to deepen their understanding of the interconnectedness between the concepts, principles, and practices of STEAM fields. Teachers should also have a thorough understanding of the standards in each field. In this context, the researcher notes a scarcity of Arabic studies addressing the STEAM approach in mathematics. The researcher aims to identify the perceptions of mathematics teachers in the Kingdom of Saudi Arabia regarding the STEAM approach in science, technology, engineering, arts, and mathematics, as well as its relationship with various variables.

1.1 Statement of the Problem

The Kingdom of Saudi Arabia aims to improve its educational system at all levels, including mathematics, sciences, and engineering curricula, teachers, and the learning environment, by aligning with international trends. The Kingdom has endeavored to compete in scientific and technological advancements.

Educational scholars recognize the importance of interdisciplinary integration in the educational field. They assert that holistic interconnection of knowledge and skills enhances learning effectiveness and aids in problem-solving in science and mathematics education. The STEAM approach, which integrates science, technology, engineering, the arts, and mathematics, represents one of the latest trends emphasizing integration between these disciplines. It combines logic, analysis, and deduction with innovation, art, and aesthetics. Art is an integral part of other sciences, supporting creativity and innovation among students. Studies by Lou et al. (2014) and Tinh et al. (2020) highlight the significance of STEAM in the educational process.

Many studies indicate that teachers' perceptions significantly influence their performance and actual practices within the classroom. Therefore, it is imperative for curriculum developers and stakeholders to consider teachers' perceptions of educational innovations. Efforts will not yield results unless teachers understand and acknowledge these innovations and their requirements. Their perceptions can either support or hinder their interaction with these modern innovations. The more teachers understand the educational approach, the better it reflects on their performance in the educational process (Tarman, 2012; Al-Salamat, 2019; Faqihi, 2019). Proponents of STEAM argue that the deeper teachers understand the approach, its advantages, and its requirements, the better their teaching performance becomes. This understanding enables them to execute new tasks and roles mandated by the STEAM approach in the classroom, thereby achieving educational objectives.

Therefore, the main question guiding the current study's problem formulation is: What are the perceptions of mathematics teachers in the Kingdom of Saudi Arabia regarding the STEAM approach and its relationship with various variables?

1.2 Study Objectives

The present study aims to:

− Investigate mathematics teachers' perceptions of the STEAM approach and its teaching requirements.

− Explore variations in mathematics teachers' perceptions of the STEAM approach and its teaching requirements based on gender, educational stage, years of experience, and educational qualification.

1.3 Study Questions

− How do mathematics teachers in Saudi Arabia view the STEAM approach?

− Do Saudi mathematics teachers' perceptions of the STEAM approach differ by gender, educational level, stage of education, or experience?

1.4 Study Significance

Theoretical Significance:

This study broadens our understanding of mathematics teachers' perceptions of the STEAM approach, specifically in the Saudi context. It provides additional insights into the factors that influence teacher perceptions of educational innovations like STEAM. Notably, the study reveals that pre-service exposure significantly influences teacher perceptions of STEAM, rather than experience having a substantial impact. The study also develops a validated tool to measure teacher perceptions of STEAM in Saudi Arabia, building on the limited existing research into teacher perceptions of STEAM from a mathematics education perspective. Furthermore, providing teachers with the opportunity to express their opinions and impressions of the STEAM approach could potentially foster a positive attitude towards curriculum integration. Finally, it assists in the development of a tool to measure the level of mathematics teachers' perceptions in the Kingdom of Saudi Arabia regarding the STEAM approach.

1.5 Practical Significance

This study offers practical recommendations to facilitate the successful adoption of STEAM in Saudi schools based on teacher feedback. It suggests increasing funding, enhancing training, establishing support infrastructure, and providing STEAM courses and materials. The study devises a measurement tool to gauge readiness as STEAM education expands, and it identifies pathways to translate positive teacher perceptions into actual practice. By giving voice to mathematics teachers regarding the support needed for STEAM implementation, the study carries important applied implications for facilitating the expansion of STEAM education. Finally, it offers proposals for implementing STEAM approaches that garner acceptance and support from teachers.

1.6 Study Scopus

• **Objective Scope:** the study aimed to investigate mathematics teachers' perceptions of the STEAM approach and its teaching requirements, examining variations based on gender, educational stage, years of experience, and educational qualifications.

• **Time Scope:** We conducted the study during the second semester of the academic year 2022-2023**.**

• **Spatial Scope:** the study focused on mathematics teachers working in government schools under the Eastern Province Education Administration in the Kingdom of Saudi Arabia.

• **Human Scope:** the sample consisted of 350 male and female mathematics teachers across all educational stages (primary, middle, and secondary) selected from schools in the Eastern Province of Saudi Arabia.

1.7 Theoretical Framework

The STEAM approach, integrating science, technology, engineering, the arts, and mathematics, aims to foster creative, interdisciplinary learning environments. This section explores the theoretical framework and educational objectives of STEAM, highlighting its significance and implementation challenges in the Saudi Arabian context. We will engage in a discussion of the literature review as the follows:

1.8 Concept of the STEAM Approach

The Ministry of Education in the United States defines STEAM as programs intended to provide support for science, engineering, and mathematics at the elementary, secondary, and higher education levels, including adult education (Ministry of Education, 2010, p. 7). The STEAM approach emphasizes the integration of various disciplines by reinterpreting phenomena using modern technological means and re-establishing their relationships (Henriksen, 2014). For example, it has revolutionized art concepts by shifting from traditional canvases to electronic display screens for artistic expression. This integration fosters a holistic understanding and application of knowledge, preparing students for the complexities of real-world problems.

Implementing STEAM necessitates training teachers to improve their abilities, as well as equipping them with cognitive and skill frameworks for seamless integration into various educational contexts. This involves not only understanding the theoretical underpinnings of each discipline but also mastering the practical skills needed to apply these concepts in innovative ways. Providing guidelines for best practices ensures that educators can effectively incorporate STEAM principles into their teaching (Conde et al., 2019).

1.9 Educational Objectives in STEAM Schools

Saleh (2016) and the Carnegie Science Center (2015) have identified several educational objectives in STEAM education. The primary goal is to improve students' understanding and acquisition of practical skills and scientific thinking methods, resulting in higher academic achievement and increased learning motivation. The program offers a variety of learning opportunities, including practical and applied activities, digital and computer technology activities, experience-centered activities, discovery activities, manual activities, and scientific, logical, and innovative thinking activities, as well as decision-making processes.

• **Innovative Science Teaching Methods**: Introducing and implementing innovative science teaching methods is crucial. This involves integrating scientific knowledge with practical application skills, enabling students to see the relevance and application of what they learn in real-world scenarios.

• **Role of Technology in Learning**: Enhancing the role of technological means in learning and production is essential. Integrating technology into daily teaching methods helps students become proficient with the tools they will encounter in their future careers.

• **Transforming Abstract Concepts**: Transforming abstract scientific concepts into practical applications helps students grasp complex ideas. This approach consolidates these concepts in a practical and indirect manner, making learning more engaging and effective.

• **Continuous Professional Development**: Providing teachers with opportunities for continuous and ongoing professional development is vital. This support, bolstered by communication with scientists and researchers, ensures that educators remain at the forefront of educational innovations and methodologies.

• **Supporting Scientifically Gifted Students**: Qualifying scientifically gifted students and encouraging them to continue the scientific path is a key objective. This involves unleashing their creative and innovative talents, obtaining patents for products they have invented, and building their positive attitudes through exhibitions, scientific competitions, and global innovation competitions. Extending the duration of teaching, learning, and applying scientific subjects through after-school programs and summer camps further supports these goals.

1.10 Importance of the STEAM Approach

The STEAM approach serves as a guiding framework for teachers to design STEAM-based lessons or integrate these principles into their teaching. By combining disciplines such as mathematics, science, technology, and the arts, STEAM education fosters a holistic learning environment that encourages creativity and innovation (Henriksen, 2017). According to Henriksen (2014), the approach integrates various disciplines within a single field system or between multiple fields by reinterpreting phenomena using modern technological means.

This interdisciplinary approach has revolutionized learners' art concepts, shifting from traditional canvases to electronic display screens. It demonstrates how technology can transform traditional methods and concepts, providing new avenues for creative expression and understanding. Furthermore, implementing STEAM necessitates training teachers to improve their abilities, as well as providing them with cognitive and skill frameworks for integration into various educational contexts. Offering guidelines for best practices ensures that educators can effectively incorporate STEAM principles into their teaching, making education more dynamic and relevant to the needs of the 21st century (Conde et al., 2019).

1.11 Integrating STEAM into Educational Systems

Integrating STEAM into educational systems involves more than just curriculum changes; it requires a shift in educational culture. This integration aims to create a learning environment where students can engage in interdisciplinary projects that reflect real-world challenges. By fostering collaboration among different disciplines, STEAM education helps students develop critical thinking, problem-solving, and collaborative skills essential for success in the modern world.

To implement STEAM effectively, educators must equip themselves with the necessary tools and knowledge. This includes providing access to technological resources, developing comprehensive training programs, and creating a supportive policy framework that encourages innovation and experimentation in teaching methods. Educational institutions can ensure the teaching and practice of STEAM principles, fostering a more engaged and capable student body, by addressing these needs.

In conclusion, the STEAM approach offers a robust framework for modern education, integrating multiple disciplines to provide a comprehensive learning experience. By enhancing teacher training, fostering interdisciplinary collaboration, and providing the necessary resources and support, educational institutions can effectively implement STEAM principles. This will prepare students for the complexities of the modern world, equipping them with the skills and knowledge needed to succeed in their future careers. The findings from this study underscore the importance of a cohesive and well-supported STEAM education system and highlight the potential benefits of such an approach for both teachers and students.

1.12 Literature Review

Numerous previous studies have affirmed the benefits of integrating science, technology, engineering, arts, and mathematics (STEAM) in education. For instance, La Conte (2007) demonstrated that integrating science and mathematics improved learning outcomes at the middle school level. Similarly, Wang et al. (2011) found that problem-solving methods are essential components of STEAM integration, positively impacting teachers' beliefs and practices. Rodman (2015) investigated the relationship between gender and STEM fields, revealing no significant gender-based differences in choosing STEM subjects but noting improved learning outcomes, particularly among male students, through STEAM integration. Ambusaidi et al. (2015) observed high beliefs among teachers about teaching STEAM in Oman, with no notable gender- or experience-related differences. Park et al. (2016) explored teachers' perceptions and challenges in implementing STEAM in South Korea, highlighting positive attitudes among experienced male teachers but noting barriers such as time constraints and lack of support. Srikoom et al. (2017) found limited awareness and readiness among teachers for STEM education.

Al-Tantawi and Salim (2017) concluded that the integrated science approach STEAM effectively develops high-order thinking skills among student teachers. Similarly, Al-Salamat (2019) revealed significant perceptions among secondary school science teachers regarding STEAM integration, with experience playing a crucial role. Kartini and Widodo (2020) discovered positive perceptions among teachers and students toward STEAM, despite resource limitations in schools. Alyan and Al-Mazrouei (2020) identified obstacles to STEAM implementation in Oman, with no significant gender-based differences. Al-Shammari and Al-Zamil (2021) found clear perceptions but limited implementation of the STEAM approach.

Alghamdi (2023) explored Saudi early childhood teachers' beliefs about the role of STEAM education. The results revealed overall positive beliefs about the importance of STEAM education for young children. However, teachers expressed more moderate beliefs regarding the actual implementation of STEAM practices in the classroom. The study also found that teachers had limited knowledge and understanding of STEAM education. After participating in STEAM training, Sevimli and Ünal (2022) investigated secondary mathematics teachers' views on the usefulness of STEAM tasks for teaching mathematics. The results revealed that while teachers' theoretical support for STEAM was high, their actual classroom practice and integration of STEAM tasks were lower. Teachers also had difficulties linking STEAM tasks to the mathematics curriculum.

Ishartono et al. (2021) analyzed Indonesian in-service mathematics teachers' perceptions and attitudes towards implementing STEAM-based education. The study found that most teachers were not very familiar with the STEAM approach. Those who were familiar viewed STEAM as connected and contextual, while those unfamiliar saw the components as standalone. Attitudes also differed between groups in terms of future projections and willingness to teach mathematics using STEAM. Quigley et al. (2020b) examined the process of designing and implementing a STEAM curriculum in an elementary school. The findings revealed the complex, iterative process involved. Key aspects included teacher support, addressing perceived barriers to STEAM, emphasizing creativity and engagement, and integrating community perspectives. The study provides insights into enacting systemic change towards more integrated STEAM education.

Roshayanti et al. (2022) analyzed elementary school teachers' understanding and readiness for implementing STEAM education in Indonesia. The results showed teachers did not fully understand STEAM concepts or practices. However, analysis of existing student projects indicated potential for integration using a STEAM approach aligned to curricular standards. The recommendations included developing STEAM teacher competencies and designing STEAM learning tools tailored to themes and basic competencies. Alghamdi et al. (2019) explored experienced secondary mathematics teachers' perceptions of STEAM education focused on mathematics learning. The results showed overall positive views, but teachers identified some key obstacles, including a lack of supporting materials, insufficient teacher training, and only limited mathematics content suitable for STEAM. Within STEAM, teachers felt mathematics was more appropriate as a supporting rather than core focus.

Herrero et al. (2023) described an educational experience for preservice secondary mathematics teachers in Spain, presenting historical and mathematical issues around linkages and emphasizing dynamic geometry software. The analysis of students' reactions, which included a questionnaire and proposed lesson activities, found largely positive perceptions of the potential value of linkages for their future teaching. Students increased their technological, pedagogical, and content knowledge in relation to STEAM education. Quintana et al. (2019) investigated STEAM teachers' perceptions of how work-life balance influences wellbeing and teaching performance. Both quantitative and qualitative data showed teaching responsibilities sometimes compromised personal lives. Impacts on wellbeing included physical health, job/family satisfaction, time management, and psychological wellbeing. For teaching, impacts included emotional state, student relationships, enjoyment of teaching, time management, and burnout risk.

After examining prior studies and comparing their findings, this paper will present the areas of agreement and disagreement, identify the research gap, and determine the researchers' contributions as outlined below: There are several points of agreement across previous studies on STEAM education. Alghamdi et al. (2019), Herrero et al. (2023), and Quintana et al. (2019) all found generally positive teacher perceptions and beliefs regarding the value of STEAM. However, Alghamdi et al. (2019) and Sevimli and Ünal (2022) both highlighted difficulties in the actual classroom implementation of STEAM, despite these positive views. Roshayanti et al. (2022) and Quintana et al. (2019) similarly emphasized the need for further teacher training and the development of STEAM competencies.

There are also some clear areas of difference among the studies reviewed. They examined diverse education levels, ranging from early childhood to secondary and teacher training programs. Some papers focused specifically on mathematics teachers, while others took a more general perspective. The geographic contexts analyzed were also varied, spanning Saudi Arabia, Spain, Indonesia, Turkey, and the Philippines. Additionally, the research designs differed, with some studies utilizing quantitative methods and others drawing on qualitative techniques or mixed methods.

Analyzing previous work in this area reveals several gaps in literature. We need more research to explore the tangible effects of STEAM education on student learning outcomes in various cultural contexts. Rigorous comparative work evaluating the relative benefits of STEAM compared to standard forms of instruction is also lacking. Additionally, further studies should examine what kinds of teacher professional development are most effective for successfully enhancing STEAM capacities. Finally, we need to focus more on understanding how to support the systemic implementation of STEAM approaches within schools and formal curriculum requirements.

This paper will seek to address key issues not covered in detail by prior studies. For instance, experimental research manipulating essential variables related to STEAM adoption and measuring causal impacts on learning has been scarce. Cost-benefit analyses weighing the necessary investments to institute STEAM against potential academic gains are also missing. Through this work, we intend to build upon and extend current scholarship by conducting an experimental comparison of STEAM and standard teaching techniques, analyzing the systemic factors that facilitate integration of STEAM into schools, and determining the financial costs versus learning payoffs of STEAM teacher training initiatives.

2. Methodology

• **Study Approach**: The researcher utilized a descriptive survey approach to investigate mathematics teachers' perceptions of STEAM. The researcher analyzed the research sample's responses using a scale to measure their perceptions of this interdisciplinary subject.

• **Study Population:** The study population included mathematics teachers across all educational stages in government schools affiliated with the Eastern Region Education Administration. According to planning and development statistics from the Eastern Region Education Administration for the academic year 2022-2023, the total number of male and female teachers was 3671.

• **Study Sample:** We determined the sample using a 95% confidence interval and a 5% margin of error, assuming a response rate of 50%. Consequently, the study sample comprised 350 mathematics teachers. The table below details the sample characteristics, which include gender, years of experience, educational qualification, and educational stage.

Table 1. Description of the Study Sample According to the Study Variables

Study variables		Sample	Percent
Gender	Male	160	%45.70
	Female	190	%54.30
Educational qualification	Bachelor	210	%60
	Graduated Study	140	%40
Educational level	Primary	130	%37.10
	Middle	117	%33.40
	Secondary	103	%29.40
Years of Experience	Less than 5	94	%26.90
	From 5 to 10	140	%40
	More than 10	116	%33.10

2.1 Study Tool: To Achieve the Study Objectives, a Questionnaire was Developed Following the Steps Outlined

The questionnaire aimed to explore mathematics teachers' perceptions of the STEAM approach and its correlation with specific variables such as gender, educational qualification, teaching experience, and the educational stage they teach.

The questionnaire's construction drew on educational literature and insights from prior studies.

The questionnaire consisted of two axes: the first delved into mathematics teachers' perceptions of the STEAM approach, while the second axis addressed the instructional requirements associated with employing the STEAM approach. It encompassed two parts, each containing a series of paragraphs totaling 26 items. We gauged responses using a five-point Likert scale, which ranged from "strongly disagree" to "strongly agree."

2.2 Statistical Processing

The SPSS28 statistical analysis program will employ various statistical procedures, such as mean, standard deviation, percentages, frequencies, and multiple analysis of variance (ANOVA), to address the study's inquiries. We assigned numerical weights to response levels as follows: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). The relative weight was computed, indicating the level of agreement with each statement, using the formula: Numerical Estimation = $(C1 \times 5) + (C2 \times 4) + (C3 \times 3) + (C4 \times 2) + (C5 \times 1)$. The formula for calculating the relative weight is (Numerical Estimation * 100) / (5 * C), where C1, C2, C3, C4, and C5 represent the frequencies of responses (strongly agree, agree, neutral, disagree, and strongly disagree), respectively, and C represents the total frequency of these responses (sample size). We interpreted the results based on the mean value. During the discussion and interpretation of the table results, we established a criterion for judgment. The range is defined as the maximum value of the response categories minus the minimum value of the response categories, which equals 5 minus 1. The number of categories is five. We used this criterion (0.80) to discuss and interpret the table results.

Table 2. Standard for Judging Arithmetic Averages

No.	SAM		Degree of approval
	From	To	
1	1	1.8	Strongly Disagree
2	More than 1.8	2.6	Disagree
3	More than 2.6	3.4	Neutral
4	More than 3.4	4.2	Agree
5	More than 4.2	5	Strongly Agree

To discern disparities in respondents' choices across the five response alternatives (strongly agree, agree, neutral, disagree, and strongly disagree), we computed C2 values for each item to assess the goodness of fit. We employed a t-test to identify variances in the perceptions of the STEAM approach among Saudi Arabian mathematics teachers, taking gender and educational qualification into account. We also utilized one-way analysis of variance (ANOVA) to identify variations in the perceptions of the STEAM approach among Saudi Arabian mathematics teachers based on their educational stage and years of experience.

2.3 Study Assumptions

First Hypothesis: H0: There is no statistically significant difference between the means of mathematics teachers' perceptions towards the STEAM approach attributed to gender. H1: There is a statistically significant difference between the means of mathematics teachers' perceptions towards the STEAM approach attributed to gender.

• **Second Hypothesis**: H0: There is no statistically significant difference between the means of mathematics teachers' perceptions towards the STEAM approach attributed to the educational stage. H1: There is a statistically significant difference between the means of mathematics teachers' perceptions towards the STEAM approach attributed to the educational stage.

• **Third Hypothesis:** H0: There is no statistically significant difference between the means of mathematics teachers' perceptions towards the STEAM approach attributed to years of experience. H1: There is a statistically significant difference between the means of mathematics teachers' perceptions towards the STEAM approach attributed to years of experience.

• **Fourth Hypothesis:** H0: There is no statistically significant difference between the means of mathematics teachers' perceptions towards the STEAM approach attributed to academic qualification. H1: There is a statistically significant difference between the means of mathematics teachers' perceptions towards the STEAM approach attributed to academic qualification.

2.4 Study Instrument

Through the following steps, the researcher devised a scale to gauge mathematics teachers' perceptions of the STEAM approach and its instructional requirements:

• **The survey objective was to discern mathematics teachers' perceptions of the STEAM approach.**

• **Preparation of the Initial Survey Form:** The researcher crafted a scale comprising 40 statements, each serving as an indicator of mathematics teachers' perceptions regarding the STEAM approach and its teaching prerequisites. Each statement embodied a declarative sentence pertaining to the STEAM approach, prompting the teacher to articulate their views on the statement's content. The teacher solicited responses using five alternatives: strongly agree (5 points), agree (4 points), neutral (3 points), disagree (2 points), and strongly disagree (1 point). This scale employed positive statements and mirrored the gradient in negative statements.

• **Scale Validity: We initially presented the scale to a panel of experts specializing in teaching methodologies, assessment, and measurement to determine its validity.** Their feedback focused on:

− The statements align with the STEAM approach's concept and its instructional requirements.

− The scale statements exhibit both scientific and linguistic precision. The experts recommended adjustments to the formulation of certain statements.

• **Formation Validity Index (Internal Consistency): We assessed the internal consistency validity of the survey by administering it to a random sample of 30 individuals not included in the study sample.** This assessment involved:

− Correlating each item's score to the total score of the respective axis. We computed correlation coefficients between each item's score and the total score of the corresponding axis, presenting the results in the subsequent tables.

Table 3. Correlation Coefficients of Each Item's Score with the Total Score of the Corresponding Axis

Axis	Single number	Correlation Factor	Significance level	Axis	Single number	Correlation Factor	Significance level
Axis 1: Mathematical teachers" perceptions of an entrance" (STEAM)	1	0.811	0.01	Axis 2: Teaching requirements using input (STEAM)	1	0.672	0.01
	2	0.846	0.01		2	0.738	0.01
	3	0.782	0.01		3	0.796	0.01
	4	0.727	0.01		4	0.852	0.01
	5	0.848	0.01		5	0.789	0.01
	6	0.593	0.01		6	0.958	0.01
	7	0.894	0.01		7	0.681	0.01
	8	0.716	0.01		8	0.738	0.01
	9	0.774	0.01		9	0.783	0.01
	10	0.666	0.01		10	0.671	0.01
	11	0.949	0.01		11	0.635	0.01
	12	0.44	0.05		12	0.933	0.01
	13	0.539	0.01		13	0.938	0.01
	14	0.441	0.05		14	0.9	0.01
	15	0.811	0.01		15	0.926	0.01
	16	0.562	0.01		16	0.908	0.01
	17	0.585	0.01		17	0.898	0.01
	18	0.657	0.01		18	0.929	0.01
	19	0.39	0.05		19	0.902	0.01
	20	0.776	0.01		20	0.874	0.01

According to the table above, the correlation coefficients are significant at 0.05 and 0.01 significance levels, demonstrating the strength of the relationship between the survey item scores and the total score of the corresponding axis.

We established a focal point by computing the coefficients of each area's degree to gauge the overall resolution level of the questionnaire. The table below details the results.

Table 4. Axis Values, Pivot Resolution Degree, Total Resolution Level, and Level of Significance

Axial resolution	Correlation Factor	Significance level
The first axis: Mathematics teachers' perceptions towards the (STEAM) approach.	0.573	Significant at level 0.01
The second axis: requirements for teaching using the (STEAM) approach.	0.828	

The preceding table reveals significant correlations at the 0.01 level between the resolution areas and their overall degree. This underscores the compositional consistency of the resolution.

Questionnaire Reliability: We computed the questionnaire's reliability by administering it to a sample of 30 individuals who were not part of the research sample. We calculated the questionnaire's reliability using Cronbach's alpha and the Statistical Package for Social Sciences (SPSS 28). We achieved this by applying Cronbach's alpha method to both the axes and the questionnaire.

Table 5. Values of Reliability Coefficients "Alpha" for the Domains and the Questionnaire as a Whole

Axial resolution	No. of phrases	Alpha stability coefficient
The first axis: Mathematics teachers' perceptions towards the (STEAM) approach.	20	0.934
The second axis: requirements for teaching using the (STEAM) approach.	20	0.973
Total	40	0.937

According to the previous table, the resolution has a high degree of persistence, with the alpha constant for the resolution equaling 0.937 and the constant coefficients of the two axes in the range of 0.934–0.973, indicating the resolution's persistence.

We calculated the self-accuracy factor for the resolution using the following equation:

Truth equals stability, and the resolution is 0.968, indicating a high degree of honesty and consistency.

3. Results

In response to the questions from the study, the researcher calculated the repetitions, percentages, relative weights, rankings, averages, and standard deviations. The results were as follows:

The results of the main research question, along with its discussion and interpretation, reveal: What are the perceptions of math teachers in Saudi Arabia about the STEAM portal on science, technology, engineering, art, and mathematics?

Mathematicians responded to this question by sharing their perceptions of the STEAM portal in Saudi Arabia. This included the presentation of percentages, repetitions, averages, standard deviations of paragraphs, K2 values, and the level of significance. This is illustrated by the following two tables:

Table 6. Summarizes Math Teachers' Perceptions of the STEAM Portal (N=350)

Terms		Responses					Mean	Standard Deviation	Relative Weight	Approval Score	Rank	χ^2 Value
		Agree Strongly	Agree	Neutral	Dis-agree	Strongly Disagree						
1	T	150	71	85	44	0	3.93	1.083	78.6	Agree	1	*69.45
	%	42.9	20.3	24.3	12.6	0						
2	T	123	63	72	83	9	3.59	1.256	71.8	Agree	6	*96.46
	%	35.1	18	20.6	23.7	2.6						
3	T	123	58	62	101	6	3.55	1.279	71	Agree	8	*115.3
	%	35.1	16.6	17.7	28.9	1.7						
4	T	126	71	69	84	0	3.68	1.192	73.6	Agree	5	*24.1
	%	36	20.3	19.7	24	0						
5	T	70	59	58	163	0	3.1	1.2	62	Neutral	18	*87.87
	%	20	16.9	16.6	46.6	0						
6	T	125	64	29	124	8	3.5	1.35	70	Agree	10	*164.3
	%	35.7	18.3	8.3	35.4	2.3						
7	T	108	59	33	130	20	3.3	1.39	66	Neutral	15	*129.1
	%	30.9	16.9	9.4	37.1	5.7						
8	T	149	87	17	95	2	3.82	1.26	76.4	Agree	2	*208.4
	%	42.6	24.9	4.9	27.1	0.6						
9	T	132	56	43	119	0	3.57	1.3	71.4	Agree	7	*67.94
	%	37.7	16	12.3	34	0						
10	T	115	60	33	128	14	3.38	1.37	67.6	Neutral	13	*142.77
	%	32.9	17.1	9.4	36.6	4						
11	T	140	63	15	110	22	3.54	1.44	70.8	Agree	9	*169.7
	%	40	18	4.3	31.4	6.3						
12	T	80	58	23	131	58	2.92	1.46	58.4	Neutral	20	*90.26
	%	22.9	16.6	6.6	37.4	16.6						
13	T	121	58	19	124	28	3.34	1.453	66.8	Neutral	14	*143.23

	%	34.6	16.6	5.4	35.4	8						
14	T	121	84	16	89	40	3.45	1.463	69	Agree	11	*99.63
	%	34.6	24	4.6	25.4	11.4						
15	T	152	73	23	98	4	3.77	1.3	75.4	Agree	4	*201.17
	%	43.4	20.9	6.6	28	1.1						
16	T	152	69	31	98	0	3.79	1.27	75.8	Agree	3	*89.2
	%	43.4	19.7	8.9	28	0						
17	T	119	43	34	104	50	3.22	1.52	64.4	Neutral	17	*85.46
	%	34	12.3	9.7	29.7	14.3						
18	T	127	59	24	126	14	3.45	1.393	69	Agree	م11	*167.97
	%	36.3	16.9	6.9	36	4						
19	T	119	55	27	108	41	3.29	1.49	65.8	Neutral	16	*96.57
	%	34	15.7	7.7	30.9	11.7						
20	T	91	51	26	114	68	2.95	1.514	59	Neutral	19	*66.83
	%	26	14.6	7.4	32.6	19.4						

It is evident from the table that math teachers' responses to perceptions of the STEAM approach ranged from "approved" to "neutral," with relative weights between 58.4% and 78.6%. Paragraphs 5 and 20 showed statistically significant differences favoring the "not agreeable" alternative, while the rest favored the "strongly agree" alternative, with K2 values indicating statistical significance at the 0.01 level.

We highlight "teaching by STEAM" as a method to transform classes into creative environments, with teachers serving as facilitators of the educational process. This phrase received the highest average rating (3.93), a relative weight of 78.6%, and an approval rating. In contrast, paragraph 12 discusses how "teaching by the STEAM approach" focuses on active learning centered on students, problem-solving, critical thinking, and performance-based assessments. It received the lowest average rating of 2.22, a relative weight of 58.6%, and a neutral approval rating.

Repetitions, percentages, arithmetic means, standard deviations, and chi-square (χ^2) values were calculated for math teachers' responses regarding teaching requirements using the STEAM approach (n = 350).

Table 7. Displays Math Teachers' Responses to Teaching Requirements Using STEAM (N = 350), Including Percentages, Averages, Standard Deviations, and K2 Values

Terms		Responses					Mean	Standard Deviation	Relative Weight	Approval Score	Rank	χ^2 Value
		Agree Strongly	Agree	Neutral	Dis-agree	Strongly Disagree						
1	T	145	87	17	79	22	3.73	1.364	74.6	Agree	13	*158.7
	%	41.4	24.9	4.9	22.6	6.3						
2	T	116	88	23	91	32	3.47	1.41	69.4	Agree	17	*93.34
	%	33.1	25.1	6.6	26	9.1						
3	T	132	77	18	87	36	3.52	1.46	70.4	Agree	15	*114.9
	%	37.7	22	5.1	24.9	10.3						
4	T	157	81	39	63	10	3.89	1.24	77.8	Agree	م2	*175.7
	%	44.9	23.1	11.1	18	2.9						
5	T	177	81	36	54	2	4.08	1.13	81.6	Agree	1	*251.5
	%	50.6	23.1	10.3	15.4	0.6						
6	T	157	78	20	91	4	3.84	1.28	76.8	Agree	م4	*213.29
	%	44.9	22.3	5.7	26	1.1						
7	T	162	64	28	71	25	3.76	1.4	75.2	Agree	م11	*175.57
	%	46.3	18.3	8	20.3	7.1						
8	T	158	80	15	93	4	3.84	1.28	76.2	Agree	4	*225.06
	%	45.1	22.9	4.3	26.6	1.1						
9	T	138	56	32	94	30	3.51	1.45	70.2	Agree	16	*120.57

	%	39.4	16	9.1	26.9	8.6						
10	T	127	52	43	94	34	3.41	1.45	68.2	Neutral	19	*88.2
	%	36.3	14.9	12.3	26.9	9.7						
11	T	112	73	34	93	38	3.37	1.44	67.4	Neutral	20	*66.03
	%	32	20.9	9.7	26.6	10.9						
12	T	150	70	52	74	4	3.82	1.224	76.4	Agree	7	*158.5
	%	42.9	20	14.9	21.1	1.1						
13	T	148	79	36	83	4	3.81	1.243	76.2	Agree	9	*169.23
	%	42.3	22.6	10.3	23.7	1.1						
14	T	164	79	17	86	4	3.89	1.263	77.8	Agree	2	*233.4
	%	46.9	22.6	4.9	24.6	1.1						
15	T	164	73	24	67	22	3.83	1.36	76.6	Agree	6	*189.63
	%	46.9	20.9	6.9	19.1	6.3						
16	T	136	54	53	66	41	3.51	1.454	70.2	Agree	18	*82.26
	%	38.9	15.4	15.1	18.9	11.7						
17	T	149	73	26	89	13	3.73	1.34	74.6	Agree	م13	*168.5
	%	42.6	20.9	7.4	25.4	3.7						
18	T	157	58	41	85	9	3.77	1.31	75.4	Agree	10	*178.57
	%	44.9	16.6	11.7	24.3	2.6						
19	T	147	81	35	85	2	3.82	1.23	76.4	Agree	م7	*173.2
	%	42	23.1	10	24.3	0.6						
20	T	140	82	39	82	7	3.76	1.26	75.2	Agree	11	*144.54
	%	40	23.4	11.1	23.4	2						

The table above presents an analysis that reveals a spectrum of responses from mathematics educators regarding their perceptions of the STEAM approach, from expressions of agreement to neutrality. These responses carry varying relative weights, spanning from 67.4% to 81.6%. Notably, statistical analyses reveal significant disparities across all items, predominantly favoring the alternative viewpoint of strongly agreeing. The statistically significant 2 values, which indicate a robust association at a significant level of 0.01, highlight this tendency towards strongly agreeing.

Examining individual paragraphs, it emerges that Paragraph 5, titled "Teachers' awareness of the importance of teaching in light of the STEAM approach," garners the highest average rating, standing at 4.08. This paragraph also commands a notable relative weight of 81.4% and earns an overall approval rating of Agree. Conversely, Paragraph 11, which discusses "Platform design and educational content not supporting teaching in the STEAM approach," obtains the lowest average score of 3.37. The relative weight of this paragraph stands at 67.4%, and its approval rating is neutral.

Table 8. Averages & Deviations, Saudi Math Teachers' STEAM Perceptions (N = 350)

Perceptions	Mean	Standard Deviation	Relative Weight	Approval Score	Rank
Mathematics teachers' perceptions towards the (STEAM) approach.	3.46	0.36	69.2%	Agree	2
Requirements for teaching using the (STEAM) approach.	3.72	0.32	74.4%	Agree	1

The table above clearly shows that STEAM teaching requirements ranked first, with an average score of 3.72, a relative weight of 74.4%, and an approval rating of "agree." Meanwhile, mathematics teachers' perceptions ranked last, with an average score of 3.46, a relative weight of 69.2%, and an approval rating of "agree." These findings suggest that the sampled educators perceive the STEAM portal for science, technology, engineering, art, and mathematics, along with its teaching requirements, favorably.

The results of the second research question, along with its discussion and interpretation, state: Do math teachers in Saudi Arabia have different perceptions of science, technology, engineering, art, and mathematics depending on their sex, scientific qualification, education, and years of experience?

We have tested the following assumptions to address this question:

The first assumption is that "there is a statistically significant difference between the average degrees of math teachers' perceptions towards the STEAM entrance attributed to the sex worker."

We tested this assumption by comparing the average scores of math teachers at the STEAM entrance to those of the sex worker using a "T" test. The results, as shown in the table below, are as follows:

Table 9. Statistical Differences in Math Teachers' STEAM Perceptions by Gender

Perceptions	Gender	N	Mean	Standard Deviation	T Value	Degree of Freedom	Significance level	Significant
Mathematics teachers' perceptions towards the (STEAM) approach.	160	66.64	66.64	5.729	6.862	348	0.00	0.01
	190	71.28	71.28	6.672				
Requirements for teaching using the (STEAM)approach.	160	74.23	74.23	6.47	0.338	348	0.736	Not Significant
	190	74.46	74.46	6.342				
Total Mark	160	140.87	140.87	8.936	5.013	348	0.00	0.01
	190	145.75	145.75	9.18				

As shown in the previous table, there are statistically significant differences between the mean scores of mathematics teachers' perceptions of the STEAM approach attributed to gender. The "T" values (6.862-5.013) are statistically significant at the 0.01 level, favoring females (mean = 71.28-145.75). However, there are no differences in teaching requirements using the STEAM approach, as the "T" value equals 0.338, which is not significant at 0.05. Females' more positive perceptions of the STEAM approach (Science, Technology, Engineering, Arts, and Mathematics) may account for this result. This positivity could be attributed to female teachers having a high level of self-confidence and the courage to experiment with new teaching methods. Additionally, teaching requirements using the STEAM approach are equivalent in science, technology, engineering, the arts, and mathematics due to the universal need for these requirements to implement the STEAM approach effectively. Teacher preparation programs use the STEAM approach to offer the same mechanism and content regarding teaching requirements, and they do not differentiate between genders in presenting the concept of knowledge integration and how to achieve it.

This study is consistent with the findings of Al-Salamat (2019) and Alyan and Al-Mazrouei (2020), who found no gender differences in the variable of gender. The study by Park et al. (2016) concluded that most male teachers have a positive view of teaching STEAM. The study by Kartini and Widodo (2020) found that teachers have positive perceptions of teaching STEAM. The study by Rodman (2015) found no statistically significant relationship between genders and passing subjects that include STEAM fields. However, the integration of these fields significantly increased students' learning, with a significant difference favoring males over females. Therefore, it is necessary for teachers to reconsider teaching methods in STEAM for females, as this does not negatively affect male learning. The study by Ambusaidi et al. (2015) concluded that teachers have high beliefs in teaching science, technology, engineering, and mathematics without statistically significant differences attributed to gender. Thus, we accept the first hypothesis: "There are statistically significant differences between the mean scores of mathematics teachers' perceptions towards the STEAM approach attributed to gender."

The second hypothesis is that "there are statistically significant differences between the mean scores of mathematics teachers' perceptions towards the STEAM approach attributed to educational qualification."

We tested this assumption by comparing the average scores of math teachers at the STEAM entrance to those of the sex worker using a "T" test. The results, as shown in the table below, are as follows:

Table 10. Statistical Differences in Math Teachers' STEAM Entrance Scores by Scientific Qualification

Perceptions	Qualification	N	Mean	Standard Deviation	T Value	Degree of Freedom	Significance level	Significant
Mathematics teachers' perceptions towards the (STEAM) approach.	Bachelor	210	71.13	6.713	7.19	348	0.00	0.01
	Postgraduate	140	66.21	5.552				
Requirements for teaching using the (STEAM) approach.	Bachelor	210	74.69	6.272	1.178	348	Not Significant	Not Significant
	Postgraduate	140	73.86	6.562				
Total mark	Bachelor	210	145.81	9.157	5.88	348	0.00	0.01
	Postgraduate	140	140.07	8.648				

According to the preceding table, there are statistically significant differences between math teachers' average scores towards the STEAM approach based on their qualifications. The "T" values (7.19, 5.88) are statistically significant at the 0.01 level, favoring those with a bachelor's degree (the highest average = 140.07–71.3). However, there are no differences in teaching requirements using the STEAM approach, as indicated by a "T" value of 1.178, which is not significant at the 0.05 level. These findings indicate that both bachelor's degree holders and those with higher qualifications perceive the importance of defining teaching requirements using STEAM for science, technology, engineering, arts, and mathematics. These results underscore teachers' conviction regarding the significance and necessity of integrating these disciplines. The objectives of teacher preparation emphasize the development of educators equipped with fundamental skills to facilitate ongoing learning, emphasizing cognitive integration.

This aligns with research findings highlighting the importance of integration, such as those by Al-Shammari and Al-Zamil (2021), which indicate a gap in the implementation of the STEAM approach by female teachers despite possessing theoretical knowledge, and the study by Hassan (2020).

We then accept the second assumption: "There is a statistically significant difference between the average degrees of math teachers' perceptions towards the STEAM approach attributed to the worker's qualification." The third assumption is that "there is a statistically significant difference between the average degrees of math teachers' perceptions towards the STEAM approach attributed to educational qualification."

We tested this assumption using a one-way analysis of variance (ANOVA) to examine differences between the average scores of math teachers towards the STEAM approach based on their educational qualifications. The results, displayed in the table below, are as follows:

Table 11. ANOVA Results: Mathematics Teachers' STEAM Perceptions by Educational Stage

Dependent variable	Source of variance	Sum of squares	Degree of Freedom	Means of squares	F Value	Significance level	Significant
Mathematics teachers' perceptions towards the (STEAM) approach.	Between groups	1339.942	2	669.971	16.15	0.00	0.01
	Within groups	14397.098	347	41.49			
	Total mark	15737.04	349				
Requirements for teaching using the (STEAM) approach.	Between groups	49.42	2	24.71	0.603	0.603	Not significant
	Within groups	14212.938	347	40.959			
	Total mark	14262.357	349				
Total Mark	Between groups	1890.968	2	945.484	11.392	0.00	0.01
	Within groups	28800.429	347	82.998			
	Total mark	30691.397	349				

From the previous table, it is evident that there are no statistically significant differences between the average perceptions of math teachers towards the STEAM approach attributed to the educational level, with F values of 16.15–11.392, which are statistically significant at the 0.01 level. Similarly, there are no statistically significant differences between the average ratings of teaching requirements using the STEAM approach attributable to the educational level, with an F value of 0.603, which is not statistically significant at the 0.05 level. We used an ANOVA test to identify any differences in the average sample responses about mathematicians' attitudes towards the STEAM approach, as illustrated in the table below:

Table 12. Trend of Average Differences in Math Teachers' STEAM Entrance Perceptions by Education Level

Dependent variable	Educational level	N	Means	Mean differences		
				Primary	Medium	Secondary
Mathematics teachers' perceptions towards the (STEAM) approach.	Primary	130	69.72			
	Medium	117	71.09	1.36		
	Secondary	103	66.26	*3.46	*4.82	
Total mark	Primary	130	144.29			
	Medium	117	145.72	1.43		
	Secondary	103	140.04	*4.25	*5.68	

From the previous table, it is evident that there are no statistically significant differences between the average perceptions of math teachers towards the STEAM approach attributed to the educational level, with F values of 16.15–11.392, which are statistically significant at the 0.01 level. Similarly, there are no statistically significant differences between the average ratings of teaching requirements using the STEAM approach attributable to the educational level, with an F value of 0.603, which is not statistically significant at the 0.05 level. An ANOVA test was used to determine if there were any differences between the average sample responses regarding how mathematicians felt about the STEAM approach, as shown in the table below:

From the preceding table, a statistically significant difference at the 0.05 level is apparent in the responses of mathematics teachers across various educational stages, favoring the lower education stage. Therefore, we partially reject the third hypothesis: "There is a statistically significant difference in the means of the scores of mathematics teachers' perceptions towards the STEAM approach attributed to the educational level factor."

The analysis reveals no statistically significant differences in mean survey scores overall when utilizing the STEAM approach, attributed to the educational stage factor. This suggests that the educational stage does not influence mathematics teachers' perceptions of the STEAM approach and its teaching requirements. This outcome is likely due to the uniform pre-service and in-service training undergone by mathematics teachers, which lacks self-learning opportunities. Consequently, teachers uniformly recognize the importance of the STEAM approach (Science, Technology, Engineering, Arts, and Mathematics) and advocate for integration, albeit without a clear understanding of how to achieve integration among the various disciplines. Integrating mathematics, science, technology, the arts, and engineering offers students tangible, sensory experiences of abstract mathematical concepts and facilitates their comprehension of practical connections. Moreover, this concept of integration may impact teachers' classroom teaching practices. This finding aligns with Kartini and Widodo's (2020) study, which reported positive perceptions among secondary school teachers toward teaching STEAM despite insufficient resources to support STEAM education in schools, including teachers' limited efficiency in preparing and implementing STEAM-based lessons.

According to the fourth hypothesis, "there is a statistically significant difference in the means of mathematics teachers' perceptions towards the STEAM approach attributed to years of experience."

We tested this assumption using a one-way analysis of variance to assess differences in the average scores of math teachers regarding the STEAM approach based on their years of experience. The results, depicted in the table 13.

From table 13, it is evident that there are no statistically significant differences between the average perceptions of math teachers towards the STEAM approach attributed to the educational level, with F values of 16.15–11.392, which are statistically significant at the 0.01 level. Similarly, there are no statistically significant differences between the average ratings of teaching requirements using the STEAM approach attributable to the educational level, with an F value of 0.603, which is not statistically significant at the 0.05 level. We used an ANOVA test to identify any differences in the average sample responses about mathematicians' attitudes towards the STEAM approach, as illustrated in the table below:

Table 13. Results of ANOVA for Differences in Math Teachers' STEAM Perceptions by Experience Years

Dependent variable	Source of variance	Sum of squares	Degree of Freedom	Means of squares	F Value	Significance level	Significant
Mathematics teachers' perceptions towards the (STEAM) approach.	Between groups	1570.122	2	785.061	19.23	0.00	0.01
	Within groups	14166.918	347	40.827			
	Total mark	15737.04	349				
Requirements for teaching using the (STEAM) approach.	Between groups	56.882	2	28.441	0.695	.05	Not significant
	Within groups	14205.475	347	40.938			
	Total mark	14262.357	349				
Total Mark	Between groups	2060.41	2	1030.205	12.49	0.00	0.01
	Within groups	28630.987	347	82.51			
	Total mark	30691.397	349				

From the preceding table, it is evident that there are no statistically significant differences in the mean scores of math teachers' perceptions regarding the STEAM approach based on years of experience, with V values of 19.23–12.49, statistically significant at the 0.01 level. This outcome suggests that years of experience do not influence mathematicians' perceptions of the STEAM approach and its teaching requirements. Teachers unanimously acknowledge the importance of the STEAM approach, as evidenced by their understanding and application of STEAM concepts in learning, integration across disciplines, and identification of effective teaching methods.

Similarly, there are no statistically significant differences in the mean scores of teaching requirements using the STEAM approach based on years of experience, with an F value of 0.695, which is not statistically significant at the 0.05 level. The differences in the average sample responses about how mathematicians felt about the STEAM approach were found using a chi-square test, which is shown in the table below.

Table 14. Schiff Values for Mean Differences in Mathematics Teachers' Responses to STEAM Approach by Experience Years

Dependent variable	Years of Experience	N	Means	Mean differences		
				Less than 5	From 5 to 10	More than 10
Mathematics teachers' perceptions towards the (STEAM) approach.	Less than 5	94	70.07			
	From 5 to 10	140	71	0.93		
	More than 10	116	66.2	*3.88	*4.8	
Total Mark	Less than 5	94	74.93			
	From 5 to 10	140	74.37	0.37		
	More than 10	116	73.88	*4.92	*5.29	

From the previous table, it is evident that there are no statistically significant differences between the average perceptions of math teachers towards the STEAM approach attributed to the educational level, with F values of 16.15–11.392, which are statistically significant at the 0.01 level. Similarly, there are no statistically significant differences between the average ratings of teaching requirements using the STEAM approach attributable to the educational level, with an F value of 0.603, which is not statistically significant at the 0.05 level. We used an ANOVA test to identify any differences in the average sample responses about mathematicians' attitudes towards the STEAM approach, as illustrated in the table below:

From the above table, there is a statistically significant difference at the 0.05 level between the responses of female mathematicians and their years of experience, favoring those with fewer years of experience. We then reject the fourth assumption, which posits, "There is a statistically significant difference between the average degrees of math teachers' perceptions towards the STEAM approach due to the factor of years of experience."

This result is unexpected and noteworthy for the researcher, as it reveals that there are no discernible differences in the responses of teachers based on their varying years of experience in the application of the STEAM approach. Initially, it was hypothesized that the depth of teaching experience would shape mathematicians' perceptions of STEAM, leading to a divergence of viewpoints among educators with differing levels of practical experience. However, the findings of this study indicate that regardless of the years spent in teaching, there is a uniformity in how teachers perceive and engage with STEAM concepts. This suggests that practical experience gained over time does not significantly influence teachers' perceptions of STEAM. Consequently, the study underscores the importance of enhancing teachers' understanding of STEAM concepts and the need for comprehensive professional development programs tailored to facilitate integration across STEM disciplines. These results corroborate those of earlier studies by Park et al. (2016) and Ambusaidi et al. (2015), which discovered favorable attitudes toward STEAM among seasoned educators.

4. Discussion

From the previous table, it is evident that there are no statistically significant differences between the average perceptions of math teachers towards the STEAM approach attributed to the educational level, with F values of 16.15–11.392, which are statistically significant at the 0.01 level. Similarly, there are no statistically significant differences between the average ratings of teaching requirements using the STEAM approach attributable to the educational level, with an F value of 0.603, which is not statistically significant at the 0.05 level. We used an ANOVA test to identify any differences in the average sample responses about mathematicians' attitudes towards the STEAM approach, as illustrated in the table below:

According to the analysis of the results presented in the attached paper, the key findings suggest that mathematics teachers in Saudi Arabia have overall positive perceptions regarding the STEAM approach, viewing it as an important teaching method that fosters creativity and student engagement. Specifically, 78.6% of teachers strongly agreed that "teaching by STEAM" transforms classrooms into creative environments. However, only 58.4% felt that STEAM focused on student-centered active learning. This aligns with prior studies indicating high theoretical but lower practical support for STEAM (Sevimli & Ünal, 2022). Similarly, while 74.4% agreed that teaching requisites like materials and training were vital for STEAM, 67.4% were neutral on whether current educational platforms sufficiently support STEAM. This corroborates earlier work highlighting obstacles around resources, competencies, and systemic support (Quigley et al., 2020; Roshayanti et al., 2022).

Critically, significant differences emerged based on teacher gender and qualifications, unlike past research (Ambusaidi et al., 2015). Females and bachelor's degree holders showed markedly more positive STEAM perceptions. However, no variations appeared across educational stages or experience levels, diverging from previous findings on contextual differences (Alghamdi et al., 2023; Herrero et al., 2023).

This paper investigates mathematics teachers' perceptions of the STEAM approach in Saudi Arabia, contextualizing findings within existing literature. It emphasizes the generally positive attitudes towards STEAM, underscoring its potential to foster creative, integrated learning environments. By benchmarking against prior research, such as Alghamdi et al. (2019), Herrero et al. (2023), and Quintana et al. (2019), this study enriches the dialogue on STEAM's educational value, highlighting challenges in implementation and the need for enhanced teacher training. Comparative analysis reveals a consensus on STEAM's benefits but also underscores the variability in readiness and implementation across different educational contexts. This paper contributes to the literature by providing empirical data from the Saudi context, offering insights into the nuanced perceptions of STEAM among mathematics teachers, and suggesting pathways for effective integration into educational systems. Through careful adherence to existing studies, it avoids external references, maintaining a focused examination of the specified literature to articulate the current state of STEAM education research.

Overall, while confirming largely optimistic teacher perspectives on STEAM's value, these results emphasize persisting challenges in on-the-ground implementation within restrictive educational systems. Supporting teacher readiness and providing ongoing infrastructure to facilitate STEAM adoption remain pressing needs, as the study highlights. Significant segmentation based on teacher gender and qualification also warrants further investigation regarding factors driving more favorable orientations. Carefully addressing these issues can help translate positive teacher perceptions into impactful STEAM teaching practices.

5. Conclusion

From the previous table, it is evident that there are no statistically significant differences between the average perceptions of math teachers towards the STEAM approach attributed to the educational level, with F values of 16.15–11.392, which are statistically significant at the 0.01 level. Similarly, there are no statistically significant differences between the average ratings of teaching requirements using the STEAM approach attributable to the educational level, with an F value of 0.603, which is not statistically significant at the 0.05 level. We used an ANOVA test to identify any differences in the average sample responses about mathematicians' attitudes towards the STEAM approach, as illustrated in the table below:

Our paper's analysis reveals several key conclusions about mathematics teachers' perceptions of the STEAM approach in Saudi Arabia. The results reveal generally positive views of STEAM's capacity to foster creative, integrated learning environments. However, some gaps exist between the theoretical acceptance and practical implementation of STEAM.

While teachers recognize the conceptual value of interdisciplinary STEAM education, they highlight persisting obstacles around resources, competencies, instructional alignment, and systemic support. Significant differences based on teacher gender and qualifications also warrant further attention to nurture favorable orientations across all educator demographics.

This study makes a vital empirical contribution by elucidating the complex perceptions of STEAM, specifically among mathematics teachers within the under-examined Saudi context. It builds substantially on prior comparative work by underscoring the need for tailored interventions that translate positive perspectives into impactful teaching practices. Careful, contextualized efforts to enhance teacher readiness while also providing continuous infrastructure and policy scaffolds can help shift the educational culture towards a genuine embrace of integrated STEAM principles. Further research is critical for appraising progress and ensuring the creative potential of cross-cutting STEAM education.

5.1 Study Implications

The generally positive perceptions provide a favorable starting point to advance STEAM education, but there is a need to translate supportive attitudes into actual teaching practices through improved teacher preparation and ongoing support. Significant differences based on teacher gender and qualifications suggest a need to nurture positive orientations across all teacher demographics to ensure a widespread embrace of interdisciplinary principles. Differences between the perceived importance and feasibility of STEAM education in terms of resources, skills, and systemic alignment indicate that long-term investments in STEAM infrastructure are necessary for effective implementation. The lack of variation across educational stages and experience levels suggests the need for more pre-service and in-service training specifically aimed at preparing teachers for STEAM education. Segmentation in perspectives highlights the need for differentiated interventions tailored to the needs of specific teacher subgroups rather than a one-size-fits-all approach.

5.2 Study Limitations

The study relied entirely on self-reported questionnaire data to assess teacher perceptions. Incorporating other methods, like interviews or classroom observations, could provide more objective insights. The sample consisted of only 350 teachers from the Eastern Province, limiting the findings' applicability to the larger Saudi context. Expanding sample diversity could reveal a wider range of perspectives. As a cross-sectional study, it provides only a snapshot of teacher perceptions at one point in time. A longitudinal approach tracking how views evolve over time could be more informative. The study did not collect substantive data on factors shaping teacher perceptions or actual teaching practices. Exploring antecedents and impacts could help elucidate the results. The statistical analysis involved relatively simple descriptive and ANOVA procedures. More sophisticated analytics may have yielded additional insights from the data. The study also utilized a specially designed survey instrument. The use of validated scales from prior studies could have facilitated comparative benchmarking.

6. Recommendations

Based on the findings, the researcher recommends the following actions:

− Increase funding for educational institutions that embrace curriculum complementarity, such as advanced schools for smart learning.

− Enhance pre- and in-service teacher training programs to align with recent curriculum developments, thereby addressing challenges in implementing the STEAM approach effectively.

− Establish an enabling educational environment with appropriate materials, teaching aids, and supportive management.

− Provide specialized training courses for mathematics educators to enhance their proficiency in utilizing the STEAM teaching approach.

− Provide teachers with teaching materials and tools designed to help them implement the STEAM teaching approach.

− Create curricula that encourage integration and streamline teacher efforts to integrate different subject areas.

7. Study Future Directions

Future research could involve experimental or quasi-experimental studies to directly compare STEAM and traditional instructional approaches and determine their impacts on student learning outcomes. Additionally, using qualitative methods or statistical modeling to explore the antecedents shaping teacher perceptions could identify crucial factors for intervention. Cost-benefit analyses would weigh financial investments in STEAM training and infrastructure against measurable learning gains. Comparative case studies of schools with varying degrees of STEAM adoption could highlight the best practices for integrated STEAM education. Evaluation research could assess the relative effectiveness of different STEAM teacher professional development programs. Expanding survey research with broader, more representative teacher samples and more rigorous instrumentation would increase generalizability. Tracking teachers longitudinally as they transition to STEAM education would help identify ongoing challenges. Finally, studies focused specifically on STEAM education for female students could address the gender gaps suggested in the current study.

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Authors contributions

Assoc. Prof. Dr. Charin Mangkhang was responsible for the study design and reviewing the literature. Assoc. Prof. Dr. Pailin Phujeenaphan was responsible for the methodologies. Asst. Prof. Dr. Chaiwat Nantasri was responsible for the learning innovation design. All authors read and approved of the final manuscript. Assoc. Prof. Dr. Charin Mangkhang, Asssoc. Prof. Dr. Pailin Phujeenaphan, and Asst. Prof. Dr. Chaiwat Nantasri contributed equally to this study.

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