Journal of Research Administration
Society of Research Administrators International

STEAM-BASED LEARNING: CHALLENGES, AND DEGREE OF EMPLOYABILITY FROM MATH TEACHERS' PERSPECTIVES

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Abstract
The study aimed to investigate the implementation of the Science, Technology, Engineering, Arts, and Mathematics (STEAM) learning approach among mathematics teachers in government schools located in the Jordanian capital, Amman. Specifically, the study explores the teachers' perspectives on the utilization of STEAM in their teaching practices, and identify the challenges they encountered during the implementation. Following a mixed-method approach, the study employed both quantitative and qualitative data collection techniques to achieve the study's objectives. The researcher utilized a questionnaire and conducted interviews with a sample of 304 teachers selected randomly from government schools in Amman. The study found that the degree of employment for the STEAM approach in teaching mathematics among teachers was moderate. Furthermore, no statistically significant differences were observed based on gender. However, there were statistically significant differences attributed to the variable of training courses, favoring those who received specialized STEAM training. Similarly, statistically significant differences were found attributed to the teaching experience variable, favoring those with five years or more of experience. Moreover, the study identified several challenges faced by mathematics teachers while implementing the STEAM approach, categorized as challenges related to the teacher, challenges related to the students, challenges related to the curriculum and content, and challenges related to the school and classroom environment. Based on the findings, the researcher provided several recommendations.

Keywords: Mathematics teachers' employment, government schools, STEAM approach, challenges.

1. Introduction

In the contemporary era, marked by rapid scientific and technological advancements, numerous facets of life have undergone profound transformations. The domain of education has not been exempted from these changes, with a recent shift towards learner-centric pedagogy, wherein educators assume the role of facilitators and guides.

One promising and modern approach in the realm of science education is the STEAM paradigm, an acronym denoting Science, Technology, Engineering, Arts, and Mathematics. Regarded as a comprehensive educational reform, its fundamental objective is to cultivate learners equipped with diverse practical skills, capable of both competing and leading in a dynamic world. This necessitates a renewed emphasis on the practical application of scientific principles within the educational framework, rooted in the integration of knowledge and its versatile application in various contexts.

Extensive research highlights that learners tend to acquire and retain information more effectively when presented with visual aids, such as images, graphics, and electronic diagrams, as opposed to relying solely on rote memorization. STEAM education contributes to enhancing attention processes and fostering profound cognitive engagement, thereby directly influencing the attainment of curricular objectives. It captivates learners' attention, facilitates comprehension of educational content, and elucidates intricate meanings and ideas. Moreover, our memory capacity for visual information seemingly surpasses that for verbal information.

Modern education underscores the importance of updating teaching strategies to encompass all aspects that prove beneficial to learners. This adaptive approach equips them with the skills to cope with the demands of the current century and navigate the ever-evolving landscape of knowledge and technological innovation. A fundamental aspect of this transformation involves transitioning learners from passive recipients of knowledge to active participants and creators in the learning process.

In this context, the theoretical literature and prior research underscore the pivotal role of teachers in designing, implementing, and evaluating the teaching process, particularly in light of the integration of science, technology, engineering, arts, and mathematics within the STEAM approach. These teacher-student relationships have evolved into essential contemporary requirements, essential for fostering excellence in mathematics teaching. Such excellence is defined by supporting students in cultivating critical mental skills, elucidating natural phenomena and scientific findings, employing scientific methodologies for inquiry and analysis, and nurturing innovative capabilities through specialized training programs that bolster every facet of the educational process.

Successful implementation of STEAM education hinges upon the fulfillment of several prerequisites. This includes empowering teachers with diverse professional and educational competencies to effectively execute the pedagogical approach. Additionally, learners bear the responsibility of advancing the economy through their future visions, which are derived from their knowledge, skills, and acquired attitudes. Lastly, curriculum development must align harmoniously with the STEAM approach to realize its full potential in shaping a generation of versatile and adept learners, primed to excel in an ever-evolving world.

The competencies required for successful implementation of the STEAM approach in mathematics education encompass three distinct domains:

1. Planning: Teachers must utilize engineering design principles to structure mathematical problem-solving strategies during lesson preparation. They should guide students in deducing mathematical concepts and skills while integrating various subjects within the STEAM framework through workshops and group activities. This approach aims to stimulate students to seek information from diverse sources and employ STEAM disciplines to address societal, vocational, and economic challenges. Moreover, scientific research methodology plays a vital role in arriving at proven solutions within this domain.
2. Implementation: This domain centers on translating educational objectives and activities into observable skills and performance among students. Teachers are tasked with fostering critical

and creative thinking abilities while providing training in digital simulations that vividly illustrate STEAM integration.

3. Evaluation: Assessment in this domain should be diagnostic, preventive, and remedial, encompassing cognitive, skill-based, and emotional educational objectives. The evaluation process is a collaborative endeavor, involving various stakeholders, such as mathematics teachers, colleagues, parents, and students themselves. Rigorous scientific foundations, including validity, reliability, and objectivity, underpin the evaluation process, which employs diverse tools like tests, interviews, observations, and achievement files.

1.1 Research Questions

What is the extent to which mathematics teachers in government schools in the capital city, Amman, employ the STEAM approach in their teaching from their perspective?

Are there statistically significant differences (at $\alpha = 0.05$) in the mean scores of the study participants regarding the extent to which mathematics teachers in government schools in the capital city, Amman, employ the STEAM approach in their teaching, attributed to the differences in study variables (gender, teaching experience, and training courses)?

What are the challenges faced by mathematics teachers during the implementation of the STEAM approach in government schools in the capital city, Amman, from their perspective?

1.2 Study Objectives

The current study aims to achieve the following objectives:

- To identify the extent to which mathematics teachers in government schools in the capital city, Amman, employ the STEAM approach in their teaching from their perspective.
- To determine if there are statistically significant differences (at $\alpha = 0.05$) in the mean scores of the study participants regarding the extent of employing the STEAM approach in teaching mathematics, attributed to the differences in study variables (gender, teaching experience, and training courses).
- To recognize the challenges faced by mathematics teachers during the implementation of the STEAM approach in government schools in the capital city, Amman, from their perspective.

1.3 The significance of the Study:

The study's importance lies in its focus on the STEAM approach in teaching, addressing a significant topic. It contributes to emphasizing the importance of employing the STEAM approach in teaching. The study can also help guiding educational leaders in creating a suitable learning environment for implementing the STEAM approach in teaching. Researchers can benefit from the current study's outputs in preparing further research studies.

2. Literature Review

Numerous educational studies and research have extolled the significance of employing the STEAM approach in mathematics teaching, citing its effectiveness. However, these studies have also illuminated challenges encountered by teachers during their implementation.

2.1 Terminology

STEAM Approach (terminologically): As defined by Koura (2017: 25), it refers to a multidisciplinary learning approach where scientific concepts are coupled with natural phenomena. Students can apply science, technology, engineering, mathematics, and arts in contexts that foster effective school-community connections, enabling them to acquire scientific culture and the ability to compete in the global economy.

STEAM Approach (operationally): In this study, the researcher defines it as an innovative solution to developing students' abilities in the fields of science, technology, engineering, mathematics, and arts. It presents this knowledge in an integrated structure, where students perceive knowledge unity and work on solving real-life problems through exploration and collaborative work.

Challenges (terminologically): "The problems or difficulties faced by teachers that prevent achieving the desired objectives of the subject" (Abdulaziz, 1426 H: 13).

Challenges (operationally): The difficulties and problems faced by mathematics teachers concerning technical, material, administrative, and environmental aspects that hinder the implementation of the STEAM approach to achieve the desired teaching objectives, measured by the tool used in the study.

2.2 Previous Studies

Among the research conducted, Al-Anizzat (2022) undertook a study to identify the obstacles to implementing the STEM approach (Science, Technology, Engineering, Mathematics) in teaching mathematics from the perspective of teachers in government schools in Ajloun Governorate. The study adopted a descriptive survey method, utilizing a questionnaire consisting of 26 statements divided into three domains. The sample comprised 130 male and female teachers randomly selected for participation. The findings revealed that the obstacles to implementing the STEM approach in teaching mathematics were perceived to be high, with the highest obstacles related to students, followed by obstacles pertaining to the educational environment, and finally, obstacles associated with the educational content. The study did not find statistically significant differences in the obstacles to implementing the STEM approach based on gender, while differences were observed in favor of higher education qualifications.

Aldelami and Alawidi (2021) conducted a study to assess the degree of employing the STEM approach in teaching physics from the perspective of teachers in Iraq. The researcher used a descriptive survey method, and the sample consisted of 108 male and female teachers from 23 schools in Anbar. The study developed a questionnaire measuring the degree of employing the STEM approach in teaching physics, consisting of 30 items distributed across three domains: planning, implementation, and evaluation. The study revealed that the degree of employing the STEM approach in teaching physics, according to the teachers' perspective, was average. The evaluation domain ranked first, followed by the planning domain, and the implementation domain ranked last. The study found no statistically significant differences in the STEM approach's implementation based on gender, academic qualifications, and experience.

Munazah and Alhenaki (2021) conducted a study to identify the obstacles to applying the STEM integration approach from the perspective of middle and high school female teachers in Saudi

Arabia. The study used an analytical descriptive method, and the sample consisted of 105 female teachers who responded to the questionnaire. The questionnaire was designed according to four domains: obstacles related to the teacher, student, educational environment, and content. The study found that the obstacles hindering the application of the STEM approach, as perceived by the math, science, and computer teachers, were of moderate agreement. The obstacles related to teachers were limited knowledge about STEM due to their university studies, while the obstacles related to students were their limited practical skills in applying the STEM approach. Obstacles related to the classroom environment included overcrowded classes and a lack of necessary classroom equipment for learning using the STEM approach. Finally, the study indicated that the STEM approach did not align well with the curriculum content.

Saleh and Abu Sara (2019) conducted a study to investigate the effectiveness of employing the STEM approach on the academic achievement of tenth-grade students in mathematics in Palestine. The sample consisted of 50 tenth-grade students, divided into two groups: an experimental group (23 students) taught the logic unit using the STEM approach, and a control group (22 students) taught the same unit using conventional methods. The study results indicated a statistically significant difference in the post-test academic achievement in favor of the experimental group.

Al-Mohamedi (2018) conducted a study to explore the effectiveness of teaching using the STEAM approach on developing problem-solving abilities among female secondary school students. The study selected a group of problems requiring knowledge and skills related to scientific content, technology, and engineering in a technological context. The study used a quasi-experimental method, employing a single-group design with pretest and posttest measures. The sample consisted of 30 purposively selected female middle school students. The study applied a problem-solving test before and after the STEAM approach was implemented, and the results showed the effectiveness of teaching according to the STEAM approach in developing problem-solving abilities among secondary school students.

James (2017) conducted a study aiming to evaluate the impact of the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach on the academic achievement of seventh-grade students in science and mathematics. The study included a sample of 631 students from Tennessee, United States. The researcher used an experimental method with two groups, one experimental group consisting of 281 students taught using the STEAM approach, and one control group of 350 students taught using the conventional method of mathematics teaching. The study used an achievement test as the research tool. The results showed that students who were taught science and mathematics using the conventional method outperformed those taught using the STEAM approach, indicating that the STEAM programs did not achieve higher levels of academic achievement in science and mathematics.

Lou et al. (2017) conducted a study aiming to investigate the effect of problem-based learning on the attitudes of high school students in Taiwan towards the integration of STEM (Science, Technology, Engineering, and Mathematics) subjects. The study sample consisted of 40 first-year secondary school students, divided into eight study groups, each involved in designing a solar-powered lift car using the principles of STEM. The researchers analyzed the learning content,

applied an attitude scale, and conducted interviews with the students. The results showed that problem-based learning can positively influence students' attitudes towards learning, future career identification, step-by-step task completion, comprehension of knowledge integration between STEM subjects, application of scientific and mathematical knowledge, and the enhancement of integration and application skills.

Al-Qahtani and Al-Khalan (2017) conducted a study aiming to identify the obstacles that prevent the implementation of the STEM approach in teaching mathematics at the middle school level from the perspective of teachers and supervisors. The researcher used a descriptive method and a questionnaire as the research tool. The study sample consisted of 103 mathematics teachers and supervisors in the Aseer region of Saudi Arabia, randomly selected. The results revealed some obstacles hindering the implementation of the STEM approach in teaching mathematics at the middle school level. The highest average was related to obstacles concerning students, followed by obstacles related to content, obstacles related to teachers, and finally, obstacles related to the classroom environment.

Olivarez (2015) conducted a study aiming to investigate the impact of a STEAM-based program on academic achievement in mathematics, science, and reading. The researcher used a quasi-experimental method, and the study sample consisted of 176 eighth-grade students from a middle school in South Texas. The students were divided into two groups: an experimental group of 73 students taught using the STEAM-based program, and a control group of 103 students taught using the conventional method. The study applied achievement tests, and the results showed that the students taught using the STEAM-based program outperformed their peers in the control group in terms of academic achievement.

In conclusion, the current study aligns with some previous studies in using quantitative research methodology, such as the descriptive survey approach used in the studies by Aneizat (2022) and Al-Dlimi & Al-Awaidi (2021). It also agrees with some studies that followed qualitative research methodology, like the study by Lou et al. (2017). However, it differs from studies that used experimental and quasi-experimental research methodologies, like the studies by Saleh & Abu Sara (2022) and Olivarez (2015).

The current study also shares similarities with some previous studies in the research instruments used to achieve its objectives and obtain results. It agrees with studies that utilized questionnaires, as seen in the research by Manzar & Al-Hanaki (2021) and Al-Qahtani & Al-Khalan (2017). Additionally, it also concurs with other studies in using interviews as a data collection method, like the study by Lou et al. (2017). However, it differs from other studies in the research tools employed, such as scales, tests, control and experimental groups, as seen in the studies by James (2017) and Al-Mahmudi (2018).

Finally, in reviewing the previous studies, it is evident that the current study stands out from others in adopting a different scientific methodology, as it combines both quantitative and qualitative approaches, unlike the methodologies used in previous studies. It also employs different research tools for data collection, namely questionnaires and interviews together.

The Study's Problem and Questions:

The effectiveness and impact of the STEAM approach in teaching mathematics, science, technology, and engineering have been validated by several studies, such as the study by Aql & Azam (2022), which highlighted the effectiveness of a science unit based on the STEAM approach in enhancing students' motivation. Also, Al-Emairi (2022) confirmed the significant effectiveness of a STEAM-based program in developing mathematical problem-solving skills and critical thinking. Moreover, the study by Koura (2017) demonstrated the significant impact of the STEAM approach in enhancing conceptual understanding and creative thinking in mathematics.

Based on the continuous updates in educational curricula, including the integration of STEAM principles, the "Unit Project" in mathematics textbooks is an example of this integration. Consequently, the researcher aimed to explore the implementation of the "Unit Project" based on the STEAM approach by mathematics teachers and identify the challenges they face during implementation. Thus, the study's problem was to determine the extent to which mathematics teachers in government schools in the capital city, Amman, employ the STEAM approach in their teaching from their perspective, and to identify the challenges they encounter during implementation.

3. Research Method

The researcher followed a mixed methodology, combining both quantitative and qualitative methods. The descriptive survey approach was used to match the study's nature and achieve its objectives in identifying the extent of employing the STEAM approach in mathematics teaching concerning certain variables. Additionally, the qualitative method of free interviews was used to discover the challenges faced by mathematics teachers during their teaching according to the STEAM approach from their perspective.

3.1 Study Scope

- Objective Scope: The study is limited to examining the employment of the STEAM approach by mathematics teachers in government schools in Amman.
- Time Scope: The academic year 2023/2022.
- Geographic Scope: Government schools in all educational directorates in the capital city, Amman.
- Human Scope: The sample includes mathematics teachers in government schools within all educational directorates of Amman, totaling 2873 teachers, including 1237 male teachers and 1636 female teachers, as per the statistics of the Ministry of Education for the academic year 2023/2022.

3.2 Study Population:

The study population includes all mathematics teachers in government schools within all educational directorates in the capital city, Amman, totaling 2873 teachers, including 1237 male teachers and 1636 female teachers, based on the statistics of the Ministry of Education for the academic year 2023/2022.

3.3 Sample of the Study:

The study sample consists of 304 male and female teachers who teach mathematics in government schools within all educational directorates in the capital city, Amman, Jordan. They were selected using simple random sampling, representing 11% of the total study population. Table number (1) illustrates the distribution of the study sample according to study variables.

Table 1 Frequencies and Percentages by Study Variables

	Categories	Frequencies	Percentage
Gender	Male	134	44.1
	Female	170	55.9
Teaching Experience	Less than a year	25	8.2
	From a year to less than 5 years	46	15.1
	More than 5 years	233	76.6
Training Courses	Obtained courses	39	12.8
	Have not obtained courses	265	87.2
	Total	304	100.0

3.4 The First Study Tool (Questionnaire)

The first study tool (questionnaire) was developed after reviewing the theoretical literature and relevant previous studies related to the current study's topic, such as Amarnah's study (2022) and Al-Awaidi's study (2021), with the aim of determining its purpose, structure, number of items, and areas of focus. The questionnaire initially consisted of 49 items distributed across three domains (planning, implementation, evaluation) representing the educational competencies required for teaching according to the STEAM approach. The items were accompanied by a Likert five-point scale (always, often, sometimes, rarely, never) to measure the respondents' answers.

The questionnaire was then converted into an electronic link and distributed to the study sample - teachers in government schools – during the second semester of the academic year 2023/2022. The questionnaire was distributed through communication channels to the directorates of education in the capital, Amman. The link was active for three weeks until the entire study sample was collected without any missing responses.

The Likert five-point scale was adopted to score the questionnaire items, assigning each item a score ranging from 1 to 5 (always, often, sometimes, rarely, never). To evaluate the means of the items, domains, and the entire tool, statistical analysis was employed using the following equation:

$$Category\ length = \frac{The\ upper\ limit - the\ lower\ limit}{The\ quantity\ of\ levels} = \frac{1-5}{3} = 1.33$$

Thus, the commitment level is categorized into three levels as follows:

- Low score (1 – less than 2.33)
- Medium score (2.34 – 3.67)
- High score (3.68 – 5)

3.4.1 Content Validity

The content validity of the questionnaire was verified by presenting it to a group of 11 experienced experts in the field of this study. They provided feedback on the linguistic accuracy of the items, the relevance of the items to the study, and the appropriateness of the domains included. Based on their suggestions, necessary modifications were made, including deletions, additions, and rephrasing, resulting in a final questionnaire with 45 items. The agreement rate reached 80%.

3.4.2 Construct Validity

To assess the construct validity of the scale, correlation coefficients were computed for each item with the total score, each item with its corresponding domain, and among the domains themselves. This analysis was conducted on a pilot sample of 30 teachers who teach mathematics in government schools within the directorates of education in the capital, Amman. The correlation coefficients ranged between 0.83 to 0.39 for the items with the entire tool, and 0.87 to 0.38 for the items with the corresponding domains, as shown in Table (2).

Table 2 Correlation coefficients between the items, total score, and the corresponding domains

Paragraph Number	Correlation ecoefficiency with the domain	Correlation ecoefficiency with the tool	Paragraph Number	Correlation ecoefficiency with the domain	Correlation ecoefficiency with the tool	Paragraph Number	Correlation ecoefficiency with the domain	Correlation ecoefficiency with the tool
1	.79**	.67**	16	.63**	.55**	31	.71**	.68**
2	.75**	.57**	17	.39*	.51**	32	.61**	.57**
3	.48**	.46*	18	.49**	.53**	33	.75**	.68**
4	.38*	.42*	19	.51**	.55**	34	.76**	.69**
5	.75**	.70**	20	.52**	.73**	35	.55**	.57**
6	.67**	.51**	21	.54**	.41*	36	.69**	.53**
7	.72**	.65**	22	.52**	.55**	37	.51**	.55**
8	.80**	.67**	23	.49**	.49**	38	.62**	.45*
9	.80**	.64**	24	.48**	.69**	39	.66**	.55**
10	.85**	.72**	25	.56**	.68**	40	.67**	.70**

11	.87**	.81**	26	.49**	.45*	41	.40*	.53**
12	.49**	.53**	27	.77**	.76**	42	.83**	.76**
13	.52**	.42*	28	.47**	.55**	43	.77**	.76**
14	.62**	.49**	29	.65**	.39*	44	.80**	.83**
15	.76**	.65**	30	.56**	.57**	45	.43*	.46*

***Statistical significance at the (0.05) level.*

***Statistical significance at the (0.01) level.*

It is worth noting that all correlation coefficients were acceptable and statistically significant. Therefore, none of these items were deleted.

The correlation coefficient between the domain and the total score, as well as the correlation coefficients between the domains, are shown in the following Table (3).

Table 3 Correlation Coefficients between Domains and the Total Score

	Planning	Implementation	Evaluation	Overall Score
Planning	1			
Implementation	.676**	1		
Evaluation	.625**	.802**	1	
Overall Score	.858**	.907**	.916**	1

Statistically significant at the significance level of (0.05).

*** Statistically significant at the significance level of (0.01).*

Table (3) shows that all correlation coefficients were acceptable and statistically significant, indicating an appropriate level of construct validity.

3.4.3 Reliability of the Study Instrument:

To ensure the reliability of the study instrument, the test-retest method was used by applying the scale and reapplying it after two weeks to a group outside the study sample, consisting of (30) teachers who teach mathematics in government schools affiliated with all directorates of education in the capital, Amman. Pearson correlation coefficients were calculated between their estimates on both occasions.

Furthermore, the internal consistency reliability was calculated using Cronbach's alpha equation. Table (4) shows the Cronbach's alpha values and the test-retest reliability for the domains, total score, which were considered suitable for the purposes of this study.

Table 4 Cronbach's Alpha for Internal Consistency and Test-Retest Reliability for Domains and Total Score.

Domain	Test-retest Reliability	Internal Consistency
Planning	0.83	0.80
Implementation	0.80	0.79
Evaluation	0.81	0.77
Overall Score	0.85	0.82

3.5 Tool (2) - The Interview:

The second tool, the interview, was developed based on the studies of Anayzat (2022) and Al-Qahtani & Al-Khalan (2017). It consisted of two questions that were merged into one question after being validated by experienced and qualified mathematics teachers and subject supervisors. The question was: "What are the challenges faced by mathematics teachers while teaching mathematics according to the STEAM approach in government schools in the capital city, Amman, Jordan, from their perspective?" The study sample included 25 mathematics teachers purposively selected from government schools in Amman, Jordan. They were individually interviewed to apply the interview tool specifically on mathematics teachers who teach in government schools within the jurisdiction of Amman's education directorates.

The interviews were conducted following a qualitative research methodology, guided by the following steps:

1. Contacting the study participants, who were purposively selected, to schedule suitable interview appointments.
2. Clearly stating the study's purpose to the participants and informing them that the data would be kept confidential and used solely for research purposes.
3. Providing suitable conditions for the interviews, showing respect and appreciation for the individuals being interviewed.
4. Conducting individual interviews with the selected study participants in person. The responses of the sample were transcribed verbatim on paper without any additions or omissions. The interview duration ranged from 10 to 15 minutes, indicating data collection stability.
5. The researcher analyzed the data using coding methodology in qualitative research, as introduced by Strauss and Corbin, following these steps:
   - Reading each interview carefully and critically several times, documenting each sentence, with the aim of extracting the ideas and themes contained in the interview data.
   - Dividing the data through open coding, where ideas and themes mentioned by the participants were coded and organized as presented in the interviews.
   - Conducting axial coding by reading the ideas present in open coding and identifying general characteristics and attributes encompassed by these ideas. After identifying the main categories, sub-ideas were included within them to arrive at final generalized attributes. The researcher ensured that the sub-ideas were expressed exactly as articulated by the interviewees.

3.6 Study Variables:

Independent Variables: There are three independent variables, as follows:

1. Gender: It has two categories: (Male, Female).
2. Teaching Experience: It has three levels: (Less than a year), (From one year to less than five years), (Five years or more).
3. Training Courses: It has two levels: (Received training courses related to STEAM), (Did not receive training courses related to STEAM).

Dependent Variable: The degree of implementation of STEAM approach in teaching mathematics by mathematics teachers in government schools in the Jordanian capital, Amman, and the teachers' perceptions (opinions) of the challenges they face during teaching mathematics according to the STEAM approach.

4. Results and Discussion

Answering the first question: What is the degree of implementation of the STEAM approach in teaching mathematics by mathematics teachers in government schools in the Jordanian capital, Amman, from their perspective?

To answer this question, the arithmetic means and standard deviations of the degree of implementation of the STEAM approach in teaching mathematics by mathematics teachers in government schools in Amman were calculated, as perceived by the teachers. The table below illustrates this:

Table 5 Arithmetic Means and Standard Deviations of the Degree of Implementation of the STEAM Approach in Teaching Mathematics by Mathematics Teachers in Government Schools in Amman, ranked in descending order based on the arithmetic means.

Rank	Number	Domain	Mean	Standard Deviation	Grade
1	2	Implementation	3.60	.486	Moderate
2	1	Planning	3.53	.550	Moderate
3	3	Evaluation	.3.47	.641	Moderate
		Overall Score	3.52	.513	Moderate

Table (5) shows that the arithmetic means ranged from (3.60-3.47), with the "Implementation" domain ranking first with the highest arithmetic mean of (3.60), while the "Assessment" domain ranked last with an arithmetic mean of (3.47). Overall, the study results indicated that the average degree of implementation of the STEAM approach in teaching mathematics by mathematics teachers in government schools in Amman, from their perspective, was (3.53), indicating a moderate level.

The researcher attributes this result to the fact that teachers in government schools still focus on traditional teaching methods, such as direct instruction and lecturing, due to various reasons, including overcrowded classrooms with large numbers of students and a lack of financial resources, educational tools, and modern technologies necessary for implementing the STEAM approach. Additionally, the study suggests that limited training of teachers in the STEAM approach and a lack of understanding of its concepts may also contribute to the observed results. Moreover, the implementation of the STEAM approach requires collaboration among all school elements, including administrators, teachers, and students.

Furthermore, the study results may be attributed to teachers' lack of knowledge of the scientific and engineering concepts acquired by the students, leading to a lack of teachers' ability to establish connections between these subjects. The researcher also points out the heavy workload on mathematics teachers, as implementing STEAM-based educational activities requires sufficient

time for designing, implementing, and evaluating lessons, which some teachers may find challenging due to concerns about losing control of the class and students' negative attitudes towards mathematics, as well as their preference for traditional teaching methods and reliance on private tutoring centers.

These results align with previous studies, such as the study by Al-Dulaimi and Al-Awaidi (2021), which showed that the implementation of the STEM approach in teaching physics by teachers in Iraq was at a moderate level.

Answering the second question: Are there statistically significant differences, at a significance level of (α=0.05), among the arithmetic means of the study participants' estimations regarding the degree of implementation of the STEAM approach in teaching mathematics by mathematics teachers in government schools in Amman, based on variables such as gender, academic qualification, and teaching experience?

To answer this question, the arithmetic means and standard deviations of the degree of implementation of the STEAM approach in teaching mathematics by mathematics teachers in government schools in Amman were calculated, based on variables such as gender, academic qualification, and teaching experience. Table (6) illustrates these results.

Table 6 Arithmetic means and standard deviations of the degree of implementation of the STEAM approach in teaching mathematics by mathematics teachers in government schools in Amman, from their perspective, based on the variables of gender, teaching experience.

		Count	**Standard Deviation**	**Mean**
Gender	Male	134	.500	3.49
	Female	170	.522	3.57
Teaching Experience	Less than a year	25	.546	3.47
	From 1 year to less than 5 years	46	.507	3.41
	More than 5 years	233	.508	3.56
Training courses	Obtained courses	Count	Standard Deviation	Mean
	Have not obtained courses	134	.500	3.49

The table demonstrates apparent variations in the arithmetic means and standard deviations of the degree of implementation of the STEAM approach in teaching mathematics by mathematics teachers in government schools in Amman, Jordan, from their perspective, due to differences in the categories of the variables (gender, teaching experience, and training courses).

To illustrate the statistical significance of the differences between the arithmetic means, a three-way analysis of variance (ANOVA) was used, as shown in Table (7).

Table 7 Three-way analysis of variance for the effect of gender, teaching experience, and training courses on the degree of implementation of the STEAM approach in teaching mathematics by mathematics teachers in government schools in Amman, Jordan, from their perespective

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Value	Statistical Significance
Gender	.603	1	.603	2.378	.124
Teaching Experience	1.574	2	.787	3.103	.046
Training Courses	2.080	1	2.080	8.198	.004
Error	75.856	299	.254		
Total	79.716	303			

The following points can be observed from Table (7):

1. There were no statistically significant differences ($\alpha = 0.05$) attributed to the effect of gender. The calculated F-value was 2.378 with a statistical significance of 0.124. The researcher concluded that the opinions and estimations of the study sample regarding "the degree of implementation of the STEAM approach in teaching mathematics by mathematics teachers in government schools in Amman, Jordan" did not differ based on the variable of gender. Both males and females showed equal attitudes towards the "degree of implementation."
   The researcher attributed this result to the similarity and uniformity of work nature and conditions in government schools in Amman, Jordan, as they share the same characteristics and operate within a compatible social and economic environment. This might have led to the absence of gender-related differences. This finding aligned with other studies, such as the study conducted by Al-Dulaimi and Al-Awadi (2021), which showed no statistically significant differences in the STEM approach in teaching physics from the perspective of teachers in Iraq based on the variable of gender.
2. There were statistically significant differences ($\alpha = 0.05$) attributed to the effect of teaching experience. The calculated F-value was 3.103 with a statistical significance of 0.046. To illustrate the pairwise statistically significant differences between the arithmetic means, the Scheffe post hoc test was used, as shown in Table (8).

Table 8 Scheffe post hoc comparisons for the effect of teaching experience on the degree of implementation of the STEAM approach in teaching mathematics by mathematics teachers in government schools in Amman, Jordan, from their perspective.

	Mean	Less than a year	From 1 year to less than 5 years	More than 5 years
Less than a year	3.47			
From 1 year to less than 5 years	3.41	.06		
More than 5 years	3.56	-.10*	-.16*	

From Table (8), the following can be observed:

1. There are statistically significant differences ($\alpha = 0.05$) between the group with "5 years or more" of teaching experience and both "less than a year" and "1 to less than 5 years" groups. The differences favored the group with "5 years or more" of teaching experience.
   The researcher attributes this result to the accumulated knowledge, practical experience, and understanding of their roles acquired by teachers with longer experience. Furthermore, those with extensive experience tend to have a clearer understanding of modern educational trends and theories in general, along with contemporary teaching strategies and methods. This leads to a preference for experienced teachers over others. This finding contrasts with other studies, such as the study conducted by Al-Dulaimi and Al-Awadi (2021), which showed no statistically significant differences in the STEM approach in teaching physics from the perspective of teachers in Iraq based on the variable of teaching experience.
2. There are statistically significant differences ($\alpha = 0.05$) attributed to the effect of training courses. The calculated F-value was 8.198 with a statistical significance of 0.004. The differences favored those who had received training courses specifically related to the STEAM approach.
   The researcher attributes this result to the fact that teachers who have taken training courses related to the STEAM approach are more capable of planning, implementing, and evaluating their lessons in line with this approach. They possess prior knowledge of the integrated STEAM methodology and know how to design activities and projects that achieve real integration between mathematical concepts and concepts related to science, engineering, technology, and arts. Additionally, they receive sufficient training on employing the STEAM approach in the overall educational process and specifically in teaching mathematics, which contributes to the positive outcome in their favor.

The third question: "What are the challenges faced by mathematics teachers while implementing the STEAM approach in teaching mathematics in government schools in Amman, Jordan, from their perspective?".

To answer this question, the responses of the study sample were analyzed using the study tool (interviews), which revealed that the challenges faced by mathematics teachers while implementing the STEAM approach in teaching mathematics in government schools in Amman, Jordan, from their perspective, are distributed as follows: challenges related to the teacher, challenges related to the students, challenges related to the curriculum and content, and challenges related to the school and classroom environment. The researcher rearranged and rephrased them as follows:

First: Challenges related to the teacher:

- Insufficient preparation of teachers before service regarding the integrated STEAM approach in teaching.
- Inadequate in-service professional development programs related to the STEAM approach.
- Heavy workload and teaching responsibilities for teachers.
- Some teachers' reluctance to teach according to the STEAM approach.
- Some teachers lack the necessary skills to use educational technology while teaching, which is essential for implementing the STEAM approach.
- Many teachers prefer traditional teaching methods for ease of planning, implementation, and evaluation.
- Some teachers are not willing to engage their students in educational activities and do not welcome their questions or inquiries.

Second: Challenges related to the students:

- Students' resistance to modern teaching methods.
- Students' lack of awareness of the STEAM approach.
- Students' deficiency in 21st-century skills, which are closely related to the STEAM approach.
- Students' lack of understanding of the importance and effectiveness of the STEAM approach in their learning.
- Low motivation of students to activate the STEAM approach during their learning process.
- Insufficient incentives for students to learn using the STEAM approach.

Third: Challenges related to the curriculum and content:

- The teacher's guide does not support the application of the STEAM approach.
- The curriculum focuses solely on theoretical aspects.
- Insufficient teaching time to apply the STEAM approach.
- The contents of the STEAM approach are not suitable for students' levels.
- The contents of the STEAM approach do not align with the curriculum content.
- The presentation style of the content lacks enthusiasm and may become monotonous.
- The curriculum does not consider individual differences among students, especially for gifted students, which does not encourage creativity.
- The curriculum lacks situations and problems that challenge students and stimulate them to search for solutions.

Fourth: Challenges related to the school and classroom environment:

- The lack of necessary classroom equipment for learning using the STEAM approach.
- The school administration's lack of interest in providing teachers with everything new related to the STEAM approach.
- The classroom environment does not promote enthusiasm and motivation among students.
- The lack of sufficient classroom equipment for learning using the STEAM approach.
- Overcrowded classrooms.
- Limited school resources and the absence of a learning resource center.
- Insufficient availability of modern computers and internet access in the school.

5. Conclusion

Through the aforementioned, it becomes evident that there are many challenges facing mathematics teachers while teaching the subject according to the STEAM approach, from their perspective. Some of these challenges, as stated by the teachers themselves, include: the large number of students, the complexity of the subject, insufficient time, very weak student knowledge and lack of cumulative information, students' seriousness amidst technological advancements, the overwhelming amount of material and side books compared to the time available, severe student weakness in mathematics, lack of familiarity with new curricula that connect STEAM with mathematics, teachers' limited experience in applying the STEAM approach, which is based on projects, problem-solving, critical and creative thinking, and scientific practices, limited learning resources, and lack of knowledge about the STEAM concept.

The researcher attributes these results to the fact that both teachers and students still prefer traditional teaching methods, such as lectures and direct instruction, due to their ease of implementation, quick results, and suitability for the school environment and available resources. Optimal use of the STEAM approach requires high levels of preparedness from both teachers and students, as well as adequate material resources and appropriate curriculum design.

This result aligns with many studies, including the study by Anizat (2022) which showed that obstacles to applying the STEM approach in teaching mathematics, from the perspective of government school teachers in Ajloun Governorate, are significant across all areas (related to students, educational environment, and content). It also aligns with the study by Al-Qahtani and Al-Kahlan (2017) which revealed some obstacles that hinder the implementation of STEM in teaching mathematics, resulting in a high estimation.

5.1 Future Recommendations:

1. Training teachers in the mechanisms of implementing the STEAM approach in their schools by organizing specialized courses on how to teach mathematics according to the STEAM approach.
2. Activating the roles of school leaders and educational supervisors in encouraging teachers to adopt the STEAM approach in their teaching by motivating them through financial and moral incentives.
3. Updating the mathematics curricula and adapting them to align with the nature of the STEAM approach, undertaken by the curriculum management.

4. Developing the school environment to accommodate STEAM activities by providing teachers with the necessary resources to teach mathematics in government schools in the capital city of Amman, following the STEAM approach.

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