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The impact of a training program for primary school teachers on developing practices based on the methodology STEAM

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Abstract

This study aimed to investigate the impact of a training program on enhancing teaching practices of elementary school teachers based on the STEAM methodology. The study employed a mixed-methods approach (quantitative–qualitative) with a sample of 10 female teachers from a private school in Amman during the first semester of the 2024/2025 academic year. Data collection tools included an observation checklist to measure teaching practices and semi-structured interviews to explore teachers' knowledge and challenges.

The training program was conducted over four days, five hours per day, focusing on problem-solving, project-based learning, inquiry-based learning, and design thinking strategies. Quantitative results indicated statistically significant differences between pre- and post-program scores in favor of the post-test, with the mean increasing from 85.92 to 92.69, a 7.9% improvement. Qualitative findings revealed enhanced knowledge of 9 teachers and a shift toward project-based and inquiry-based teaching practices, despite ongoing challenges related to resources, time constraints, and curriculum load.

The study recommended continuous training programs, the establishment of professional learning communities, supportive learning environments, and restructuring of the school timetable and curriculum.

Keywords: STEAM methodology, teaching practices, elementary stage, training program, problem-solving, project-based learning, design thinking, inquiry-based learning.

Introduction:

In recent decades, the education system has witnessed a radical transformation towards adopting interactive and integrated educational models that respond to the requirements of the digital revolution and technological progress. This methodology STEAM is one of the most prominent of these contemporary trends, integrating science, technology, engineering, arts, and mathematics into an educational context that fosters critical thinking, creativity, and problem-solving—essential skills for 21st-century learners. With the accelerating digital transformation and increasing reliance on smart and interactive learning technologies, it has become imperative to equip teachers with teaching skills that are compatible with digital learning environments and that employ technology in meaningful, real-world contexts.

Modern educational trends seek to improve the quality of education by adopting integrated curricula that prepare students for the demands of the 21st century. This methodology is STEAM is one of the most prominent of these curricula, as it integrates science, technology, engineering, arts, and mathematics, developing critical thinking, creativity, and problem-solving (Randa et al., 2022; Subekti et al., 2024). In this context, the importance of empowering teachers in the primary stage is highlighted in accordance with the Jordanian national framework, which emphasizes their role in preparing learners for life (Zantout, 2024; General Framework for Jordanian Curricula, 2024). However, obstacles such as poor training, limited resources, and weak integration between disciplines limit the realization of this approach (Al-Shammari et al., 2022; Afzal & Tandel, 2025).

The study confirmed that Ahmad, (2025) stated that improving teachers' digital competence contributes to raising the quality of education and achieving the Sustainable Development Goals. Several studies have also emphasized the importance of vocational training in facilitating the implementation of the STEAM methodology. Quigley et al.'s (2020) study indicated that training programs that employ STEAM strategies contribute to increasing the effectiveness of learning in classrooms, while Boice et al.'s (2021) study demonstrated that specialized training enables teachers to overcome challenges such as limited resources or a general understanding of the methodology.

Based on these data, the current study aims to investigate the impact of a training program specifically designed for primary school teachers in a private school in the capital, Amman, during the first semester.2024/2025, with the aim of developing their teaching practices according to the STEAM methodology. The program focuses on innovative educational strategies that include problem-solving, project-based learning (PBL), inquiry-based learning, and design thinking, while employing technology and artificial intelligence to enhance interaction and creativity in the learning environment.

Study problem

Primary school teachers face multiple challenges in implementing the methodology. STEAM as an educational framework enhances students' critical thinking, creativity, and problem-solving skills. Despite the importance of this methodology in improving the quality of education, Al-Shammari et al.'s (2022) study indicated that science teachers face difficulties in implementing STEM integration due to a lack of training. Ahmad (2024) recommended the need to provide specialized training programs for faculty members and improve technical infrastructure at universities.

Boice et al. (2021) confirmed that ongoing training support is essential for understanding and implementing STEAM. This aligns with the findings of Al-Harbi's (2022) study, which showed that current programs are insufficient to enable teachers to adopt innovative practices. In the same context, Vachhiyat & Tandel (2025) indicated that teachers still face challenges related to their perceptions and capabilities, reinforcing the need for effective training programs. Subekti et al.'s (2024) study also demonstrated that integrated training contributes to enhancing teachers' ability to design activities that combine arts and sciences, enhancing student engagement and motivation.

Based on this literature, the gap in training primary school teachers in line with the requirements of the methodology becomes clear. STEAM forms the basis of this study, which aims to investigate the impact of a proposed training program on developing teaching practices. The program is based on innovative educational strategies, including problem-solving, project-based learning (PBL), inquiry-based learning, and design thinking, while integrating technology and employing artificial intelligence to enhance interaction and creativity in teaching. The study seeks to answer the main question:

1- What is the impact of a training program on developing the teaching practices of primary school teachers using the STEAM methodology?

Study hypothesis:

There is a statistically significant difference at the level of ($\alpha \leq 0.05$) between the average scores of primary school teachers on the observation card of teaching practices based on the STEAM methodology, attributed to the application of the training program, between the pre- and post-measurements.

Importance of the study

The theoretical importance of this study stems from its contribution to enriching educational literature by deepening the understanding of the impact of training programs based on the methodology. STEAM (Science, Technology, Engineering, Arts, and Mathematics) is used to develop teaching practices among primary school teachers. It also contributes to bridging a research gap related to integrated vocational training by providing a theoretical framework that links academic and practical dimensions to enhance teaching competencies in accordance with the integrative approach of the STEAM methodology.

The practical importance of this study lies in the design and implementation of a training program based on the methodology. STEAM contributes to developing the competency of primary school teachers and improving their classroom practices, in line with the National Center for Curriculum Development's (NCCD) orientation toward integrative education in Jordan. By equipping teachers with modern educational strategies such as inquiry-based learning and design thinking, the program enables students to improve learning outcomes and enhance their engagement and motivation to learn. It also helps teachers overcome challenges associated with implementing the methodology, such as limited resources or a general understanding of its requirements, as confirmed by previous studies such as Quigley et al. (2020) and Boice et al. (2021). Furthermore, the program opens the way for teachers to design integrative learning activities that combine arts and sciences, contributing to a more creative and interactive learning environment, as demonstrated by Subekti et al. (2024).

Study limitations and boundaries

The current study was defined by the following limitations:

Time limits: The study was implemented during the academic year.2024/2025, specifically during the first semester. Spatial boundaries: The study was implemented in a private school affiliated with the Ministry of Education in the capital, Kuwait. Objective boundaries: The study was limited to the impact of a training program for primary school teachers to develop teaching practices based on the STEAM methodology.

Study limitations the sample consisted of10 primary school teachers who participated. The study results were determined based on an assessment of the validity and reliability of the tools used. The results can only be generalized to the community from which the study sample was collected and to similar communities. The results were also determined based on the participants' honesty and objectivity in their responses to the items in the tool used.

Study variables: This study addresses the following variables:

Independent variable: The training program based on the methodology. STEAM

Dependent variables: teaching practices of primary school teachers.

Operational definitions

Training Program: It is procedurally defined as a set of training sessions and educational activities that are designed to enhance the skills of primary school teachers in applying the methodology STEAM, which was implemented during the first semester of the 2024/2025 academic year at a private school in the capital, Amman.

Primary school teachers: They are procedurally defined as the participants in the study, and they are:10 female teachers from a private school operating under the supervision of the Ministry of Education in the Amman Governorate will teach grades one through six during the first semester of the 2024/2025 academic year.

Methodology STEAM It is procedurally defined as the integrative educational approach that links sciences, Technology, Engineering, Arts, and Mathematics within an interconnected framework based on practical application and real life, formed the theoretical and practical framework for designing the training program and measuring teachers' practices through interviews and classroom observations.

Theoretical literature and previous studies

The need arose to STEAM addresses the lack of creativity in traditional STEM, with the addition of the arts to create a more holistic learning experience. The STEAM methodology emerged as a natural evolution that integrates science, technology, engineering, the arts, and mathematics within an educational framework focused on interdisciplinary integration and inquiry-based learning (Nguyen, 2025). STEAM is defined as an educational approach that encourages creative thinking and problem-solving by integrating the arts with scientific disciplines, fostering innovation and providing a comprehensive learning environment (Kizhukarakkatu, 2025).

Methodology STEAM Importance and Application in the Educational Process:

The methodology is STEAM is an integrative educational framework that links science and the arts, enhancing students'

communication, creativity, and collaboration skills and enabling them to address challenges in innovative ways (Alkhatib, 2025; Asrifan et al., 2025). It is based on constructivist theory and the principles of Piaget and Vygotsky, where learners learn through experience and social interaction (Zin et al., 2024). It also employs strategies such as project-based learning and design thinking to develop analytical thinking and teamwork (Juliangkary et al., 2024). It is linked to authentic assessment, which measures students' ability to apply knowledge to real-life situations, beyond traditional tests (Qablan et al., 2024).

Professional development and training programs in context STEAM

Professional development is defined as a continuous process of developing teachers' cognitive, technical and professional skills to meet contemporary educational challenges (Zantout,2024). In the context of STEAM, it focuses on enabling teachers to move from traditional teaching to interdisciplinary practices, such as designing activities that combine science and art, such as creating engineering models with simple materials (Boice et al., 2021).

Confirm Silva-Hormazábal & Alsina (2023) argue that professional development transforms teachers into effective human resources, while Roshayanti et al. (2022) suggest that teachers' professional readiness is the cornerstone of STEAM success, requiring ongoing training to build their confidence. Studies indicate that the quality of training programs depends on their relevance to teachers' actual needs and the requirements for implementing the STEAM methodology in the school context.

Model enhances TPACK integrates technological, pedagogical, and content knowledge, supporting the design of integrated learning experiences (Koehler & Mishra, 2023). Professional learning communities (PLCs) encourage collaboration among teachers to develop practices through shared reflection (DuFour & Fullan, 2023).

A study confirmed that Segarra-Morales & José (2024) emphasized the importance of a practice-based training model, which allows teachers to apply what they have learned in a real teaching context, while providing ongoing feedback. Behera et al. (2025) also indicated that models that effectively integrate technology into training enhance teachers' confidence and improve their readiness to implement the methodology.

Previous studies

The researcher presented the most important studies that revealed the importance of STEM/STEAM in teacher training and qualification in general and is sequenced from oldest to newest.

Al-Mutairi's study aimed to:(2023) to identify the effectiveness of an enrichment teaching program based on the STEM approach in developing 21st-century skills among middle school students. The study adopted a quasi-experimental approach with a two-group design and included a sample of 60 second-grade middle school students, divided into an experimental and a control group. The study used an electronic questionnaire as the primary tool to measure critical thinking and creativity skills. The results showed a significant improvement in the performance of the experimental group compared to the control group, with statistically significant differences in favor of the experimental group. The study recommended implementing STEM-based teaching programs to enhance 21st-century skills and training teachers to design enrichment activities.

Sharaf al-Din's study sought to (2023) to investigate the effectiveness of a training program based on the STEM approach in improving the teaching performance skills of female student teachers. The study used a descriptive, quasi-experimental approach with a single-group design, and included a sample of 22 female students from the fourth-year physics department, who were intentionally selected. An observation scale was used to assess teaching performance skills as a study tool. The results showed statistically significant differences between the pre- and post-tests in favor of the post-test, with a continued positive effect on the follow-up test. The study recommended STEM-specific courses in teacher preparation programs and providing a supportive learning environment to apply acquired skills.

Al-Hamouri's study aimed to: (2023) & (tabieh, Fayiz, Altawalbeh, & Ahmad, 2024) To identify the difficulties of implementing the STEM approach in teaching science at the primary level and propose practical solutions. The study adopted a descriptive-analytical approach and included a sample of 60 teachers in public schools, who were intentionally selected. The study used a questionnaire to measure the difficulties and proposed solutions. The results revealed moderate difficulties in implementing STEM, most notably the lack of technological tools and specialized training programs. The study proposed developing intensive training programs, providing modern educational resources, and strengthening institutional support.

The study investigated Mehddi et al. (2024) The impact of professional development programs on enhancing the integration of the STEAM methodology into teachers' practices. The study adopted a descriptive approach, using questionnaires and field observations as study tools, and was applied to a sample of teachers participating in a professional training program. The results showed a significant improvement in the integration of disciplines and an increase in teachers' ability to design integrative educational activities, despite ongoing challenges such as a lack of educational resources. The study recommended the continuation of training programs and the provision of the necessary resources to support the implementation of STEAM in schools.

Al-Faraj's study investigated ((2024) The impact of an environmental modeling-based professional development program on enhancing science teachers' perceptions of STEAM implementation. The study adopted a qualitative approach and included a sample of 17 purposively selected teachers. Semi-structured interviews were used before and after the program as the primary data collection tool. The results showed a partial improvement in positive perceptions of STEAM, although challenges such as a lack of professional qualifications, limited resources, and weak institutional support persist. The study recommended the design of comprehensive training programs that include practical applications, along with providing ongoing institutional support to improve teachers' efficiency.

Al-Subhi's study focused on: (2024) to investigate the effectiveness of the STEAM integration curve in improving the quality of the educational process. The study adopted a descriptive-analytical approach and included a systematic review of 40 studies published between 2010 and 2020 as a study tool, without relying on a direct human sample. The results showed that the application of STEAM contributes to promoting an active learning environment and developing problem-solving and creative thinking skills, reflecting the methodology's potential to improve the quality of education. The study recommended mainstreaming the STEAM approach into

school curricula, with a focus on developing training programs for teachers.

Zantout's study aimed to: (2024) to develop the professional development of primary school teachers in accordance with the requirements of the STEM methodology. The study adopted a theoretical approach, used document analysis and previous studies as research tools, and focused on a documentary analysis of current curricula and training needs. The results revealed an urgent need for institutional support and ongoing training for teachers to implement STEM in early education. The study proposed the establishment of specialized training centers and the design of integrated activities that meet the needs of students in the primary school cycle.

The study by Bani Ahmad (2025) aimed to explore faculty members' use of digital learning tools in Jordanian universities and the challenges they face. The results showed a high level of digital tool usage, with differences related to the type of university, colleges, and academic level, and a high level of challenges associated with digital learning. These findings align with Subekti & Mukodas (2025), who indicated that vocational training enhances teachers' digital competencies and intercultural skills, positively impacting teaching performance and student learning outcomes, emphasizing the integration of technology and the design of collaborative practical activities in training programs. Accordingly, the studies recommended adopting digital learning based on technical, educational, and scientific principles and developing university infrastructure to overcome future challenges.

The study dealt with Behera et al. (2025) investigated primary school teachers' attitudes toward STEAM implementation, focusing on the impact of training on these attitudes. The study adopted a descriptive approach and used a questionnaire to measure attitudes and confidence in the implementation as a study tool. The questionnaire was administered to a sample of primary school teachers. The results showed that ongoing training plays a pivotal role in fostering positive attitudes toward STEAM, as trainee teachers reported increased confidence and ability to design integrated lessons. The study recommended designing training programs that focus on practical applications, integrating technology and integrated activities.

Comment on previous studies

The current study aligns with the findings of previous research regarding the impact of training programs on enhancing teachers' practices in the STEAM context. For example, Al-Mutairi (2023), Sharaf Al-Din (2023), and Al-Faraj (2024) reported improvements in teaching competencies despite ongoing challenges such as lack of training, weak interdisciplinary integration, and limited resources, with proposed solutions including intensive training, technology integration (Subekti & Mukodas, 2025), and establishment of specialized training centers. Similarly, Qawaqneh, Ahmad, and Alawamreh (2023) highlighted the role of technology-enhanced learning environments in improving students' motivation and engagement, supporting the integration of digital tools in training programs.

Building on these recommendations, the present study developed a technology-supported training program focusing on the practical application of designing integrated lessons following the STEAM methodology. It employed a mixed-methods approach (observation cards and semi-structured interviews) to analyze teachers' experiences and measure their performance, targeting primary

school teachers in Jordan and the four STEAM strategies (inquiry, problem-solving, active learning, design thinking). This study addresses a local research gap in practical teacher training and supports the directions of the National Center for Curriculum Development (2024).

Study methodology

The study adopted a mixed-method approach, combining quantitative and qualitative approaches to achieve its objectives in an integrated manner. Using the quantitative approach, changes in teachers' teaching practices were measured using an observation card. Conversely, the qualitative approach—through semi-structured interviews—allowed for an in-depth exploration of teachers' experiences, revealing the nature of improvements in their knowledge, as well as changes in teaching methods and the challenges they faced.

Participants

The study community consisted of 42 primary school teachers at a private school in the Capital Governorate of Kuwait during the first semester of the 2024/2025 academic year. These teachers teach grades 1 through 6 and have diverse specialties. This community was selected to represent the target group for the training program.

A purposive sample of 10 female teachers (M1 to M10), representing 23.8% of the population, were recruited based on a needs analysis conducted through a questionnaire that included 42 female teachers. The questionnaire showed weaknesses in design thinking (mean 3.38 out of 5) and inquiry-based learning (mean 3.45 out of 5), which justified the sample selection. The teachers' experience ranged from 4 to 15 years, reflecting a diversity of professional backgrounds (Bahari & Saleh, 2024). Participants' consent was obtained after explaining the study objectives and ensuring the confidentiality of their data.

Study tools

Instruments included an observation card and semi-structured interviews to collect quantitative and qualitative data.

A. Observation card

The study relied on an observation card as the primary tool for evaluating teachers' teaching practices in the classroom, before and after the training program. The card was designed according to a comprehensive methodological framework based on methodological foundations. STEAM, which considers the integration of disciplines (science, technology, engineering, arts, and mathematics), and utilizes active learning strategies such as problem-solving, project-based learning, inquiry-based learning, and design thinking. Care was taken to ensure that the curriculum is comprehensive and accurate, enabling teachers to objectively and systematically monitor their teaching practices.

Honesty and steadfastness:

Tool validity: To ensure content validity, the observation card was presented to a group of judges specialized in curricula, teaching methods, and learning-based education. STEAM, and their feedback was taken into account when finalizing the tool.

Tool stability reliability was verified through Cronbach's alpha coefficient after the pilot application on a survey sample consisting of (10) Parameters, where the reliability coefficient reached (0.88), which is an indicator of high internal consistency and the suitability of the card for use in the context of the current study.

B. Semi-structured interviews

The interviews were designed to collect qualitative data about the teachers' experiences and covered six themes: educational background, understanding of methodology, STEAM, application of instructional strategies (problem solving, PBL, inquiry-based learning, design thinking), training needs, school environment, and performance evaluation. Interviews were conducted twice for each teacher (before and after the program), each lasting 45 minutes, and were documented in writing with the participants' consent. Questions were developed in consultation with educational experts, and a pilot was conducted with an outside teacher to ensure clarity and relevance of the questions.

Study procedures

The study was implemented through the following stages:

Needs Analysis: A survey was conducted that included 42 teachers were surveyed to identify gaps in knowledge and practices related to STEAM methodology and instructional strategies.

Program Design: Designed based on survey results, with a focus on collaborative learning, technology integration, and developing problem-solving strategies. PBL, inquiry-based learning (guided and free), and design thinking.

Program implementation: It was held over four days in a training room equipped with digital tools. Class Point, Kahoot, Padlet, Google Forms), in which 42 teachers participated, with a sample of 10 teachers being followed up to evaluate the impact.

Quantitative data collection: Two classes were observed for each teacher from the sample (20 sessions: 10 before and 10 after) Using an observation card to measure changes in practices.

Qualitative data collection: Pre- and post-interviews were conducted with the sample to understand their experiences and challenges in implementing STEAM.

Ethical considerations: Written consent was obtained from participants, and identification numbers were used. M1) to (M10) to ensure confidentiality, with the possibility of withdrawal without consequences, in accordance with ethical standards in scientific research.

Research design

The study adopted a mixed-methods design, combining quantitative measurement via observation cards with qualitative exploration via interviews, to test the hypothesis of statistically significant differences in practices and gain a deeper understanding of teachers' experiences. This design enhances the accuracy of measurement and the comprehensiveness of analysis.

Statistical processing

Quantitative aspect

The test was used Wilcoxon signed ranks test to compare observation card scores before and after the program, due to the small sample size (10 parameters) and the possibility that the data may not follow a normal distribution.

Qualitative aspect

Thematic analysis was used to manually transcribe the interview transcripts, by transcribing the transcripts, reading them multiple times, coding the data, and categorizing the codes into themes (e.g., improving knowledge, challenges in application). STEAM, and linking it to the research questions.

Coding system used in qualitative data analysis

To analyze the qualitative data extracted from the semi-structured interviews in a systematic and organized manner, a comprehensive coding system was developed that aligned with the study's sub-questions. This system was divided into three main axes that reflect the study's central dimensions:

The first axis: teachers' knowledge of the methodology) STEAM is related to the first sub-question)

C1: Understanding the STEAM concept - This includes the teacher's awareness of the comprehensive concept of the STEAM methodology and its various dimensions.

C2: Knowledge of Interdisciplinary Integration - reflects the teacher's understanding of how science, technology, engineering, arts, and mathematics are linked and integrated.

C3: Knowledge of teaching methods using STEAM - indicates the teacher's familiarity with the appropriate teaching strategies for applying the methodology

C4: Awareness of the importance of STEAM in education - This includes the teacher's awareness of the value and impact of the methodology in improving students' learning and developing their skills.

Axis II: Changes in teaching practices (related to the second sub-question)

P1: Lesson Planning - Includes the development of teacher methods in designing and planning lessons in line with the STEAM methodology

P2: Teaching Strategies - reflects the change in strategies used, including project-based learning, inquiry-based learning, and design thinking

P3: Assessment Methods - addresses the shift in methods of assessing student learning from traditional methods to performance-based assessment.

P4: Classroom Management - refers to the change in the teacher's ability to manage the classroom while implementing interactive STEAM activities.

P5: Technology Integration - This includes the development of the teacher's use of technological tools in teaching.

P6: Enhancing Thinking Skills - reflects the change in the teacher's focus on developing students' higher-order thinking skills.

Axis 3: Challenges (related to sub-question 3)

CH1: Resource-related challenges - include barriers related to the availability of tools and equipment needed to implement the STEAM methodology

CH2: Time-related challenges - These include difficulties related to time constraints and a busy school schedule.

CH3: Curriculum-related challenges - reflecting the constraints imposed by the curriculum's momentum and traditional nature

CH4: Training/Skills Challenges - refers to the lack of competencies and skills needed to apply the methodology effectively.

This coding system was used in the systematic analysis of the interviews, where teachers' responses were categorized according to the specified codes, enabling accurate monitoring of changes in

their knowledge, practices, and the challenges they faced. Following initial coding, the categories were reviewed for accuracy and consistency, and the coded data were then compiled into tables showing frequencies and percentages, with verbatim quotes from teachers' responses included as supporting evidence.

Show results

The researcher presents the results of a mixed study (quantitative and qualitative) that aimed to evaluate the impact of a training program in developing the teaching practices of primary school teachers using a methodology. STEAM The study focuses on answering the main question: What is the impact of a training program on developing the teaching practices of primary school teachers using the STEAM methodology?, and the following sub-questions:

The hypothesis is that there is a statistically significant difference at the significance level ($\alpha \leq 0.05$) between the average scores of primary school teachers on the observation card of teaching practices based on the STEAM methodology before and after the program. Data were collected through formal interviews and an observation card conducted with ten teachers (M1 to M10) before and after the training program.

The quantitative results are presented in a separate section for hypothesis testing, while the qualitative results are presented in three sections, each of which includes a brief table showing the frequencies of affected and unaffected parameters, followed by a detailed table showing quotations, with a descriptive textual description. The chapter is divided into four sections: the results of the hypothesis testing (quantitative), the results of the sub-questions (qualitative), and the results of the sub-questions (qualitative).

Hypothesis Test Results (Quantitative Results)

Teaching practices were measured using a multi-aspect observation card, and the performance of the ten teachers in real teaching situations was analyzed. These quantitative data provide a basis for testing the study hypothesis regarding the existence of a statistically significant difference between the teachers' mean scores before and after the training program, as shown in Table (1). table1: Arithmetic means and standard deviations of the scores of participating teachers on the observation card of teaching practices based on the STEAM methodology before and after implementing the training program.

standard deviation	arithmetic mean	number	stage
4.89	85.92	10	Tribal note
5.12	92.69	10	Post-observation

It is clear from the table (1) There is an apparent difference between the arithmetic mean of the teachers' scores before and after the training program, as the mean increased from 85.92 in the pre-observation to 92.69 in the post-observation, an increase of 6.77 points. It is also noted that the standard deviation values were close in the two stages (4.89 and 5.12), respectively, indicating a relative homogeneity in the teachers' performance before and after the program. This increase in the arithmetic mean provides a preliminary indication of the effectiveness of the training program in developing the teachers' teaching practices, but a statistical test is required to verify the significance of this difference.

To test the significance of the difference between the average scores of the teachers before and after the training program, a test was used. Wilcoxon Signed Ranks is non-parametric, due to the small sample size (10 parameters) and the inappropriateness of

parametric tests in this case. Table (2) shows the results of this test, including the distribution of ranks, the value of the Z statistic, and the significance level.

table2: Wilcoxon Signed Ranks Test Results for Differences in Teacher Practices

Significance	value of "z"	Total ranks	Average rank	number	ranks
-2.803	0.00	0.00	0	negative ranks	Post-test - Pre-test
	55.00	5.50	10	positive ranks	

Test results indicate Wilcoxon test shown in Table (2) indicates the presence of a statistically significant difference at the significance level ($\alpha \leq 0.05$) between the teachers' average scores before and after the training program, with a value of $Z = -2.803$ and a significance level of 0.005. It is noted that all ranks were positive (10 ranks) with an average of 5.50, which means that all teachers showed improvement in their teaching practices after the program, and that this improvement was relatively close. Based on these results, the research hypothesis can be accepted, which states that there is a statistically significant difference between the teachers' average scores before and after the training program, which

confirms the effectiveness of the program in developing teaching practices based on the STEAM methodology.

Answering the first research question:

To what extent does the training program contribute to improving teachers' knowledge of the methodology? STEAM? To achieve this, data from teacher interviews was analyzed and coded into four main categories that reflect aspects of knowledge of the methodology. Table (3) provides a summary of the number of teachers who showed improvement in each aspect, identifying teachers whose knowledge of the program was not affected.

table3: Summary of the frequency of parameters affected and unaffected in knowledge of the STEAM methodology

Unaffected parameter codes	Number of affected parameters	The concept
M5	9	Understanding the concept STEAM
M5, M10	8	Integration between fields
M5, M9, M10	7	Teaching methods
M5	9	Awareness of the importance of STEAM

It is clear from the table (3) The training program contributed significantly to improving the majority of teachers' knowledge of the STEAM methodology. 9 out of 10 teachers showed an improvement in their understanding of the STEAM concept (C1) and awareness of its importance (C4), while 8 teachers' understanding of integration between fields (C2) and 7 teachers' understanding of appropriate teaching methods (C3) improved.

not others. This variance in teacher responses may be attributed to personal factors such as teaching experience, academic specialization, or intrinsic motivation, necessitating the design of training programs that account for individual differences among teachers.

It is also noted that the teacher M5 was the least responsive to the program, showing no improvement in any of the four knowledge areas, while M9 and M10 showed improvement in some areas but

Table (4) A detailed comparison of their knowledge levels before and after the training program in each of the four knowledge aspects. The comparison includes a brief description of the situation before and after the program, supported by verbatim quotes from interviews with the teachers.

The code	Category	After the training program	Before the training program
C1	Understanding the concept STEAM	Comprehensive practical understanding, focused on integration and problem solving. Quote (M10): "I came to understand that STEAM is an approach that integrates materials to solve real-world problems." Quote (M7): "I understood that STEAM connects materials in a way that makes learning fun and practical."	Limited theoretical understanding, based on informal sources. Quote (M8): "I have theoretical knowledge of the STEAM methodology...an educational approach that links science and technology." Quote (M1): "I have some theoretical knowledge of the STEAM methodology, but I have not had sufficient knowledge of it."
C2	Integration between fields	Clear understanding of field integration, with practical examples. Quote (M2): "I designed an activity that linked science and technology using robotics." Quote (M4): "I combined art with math to design geometric shapes."	Vague understanding, focus on teaching material independently. Quote (M10): "I think each subject should be taught independently." Quote (M5): "I'm not entirely sure of its exact concept."
C3	Teaching methods	Various methods include project-based learning. Quote (M3): "I started using problem-based learning in science lessons." Quote (M6): "I used design thinking strategies to design	Absent or limited methods, focus on traditional explanation. Quote (M3): "I tried to incorporate some simple elements." Quote (M2): "I didn't know how to apply STEAM

		engineering projects.”	systematically.”
C4	Awareness of the importance of STEAM	Specific awareness focused on 21st century skills21. Quote (M9): “STEAM enhances students’ creativity and collaboration skills.” Quote (M1): “I realized the importance of STEAM in motivating students to think independently.”	General awareness without specific details. Quote (M4): “STEAM methodology is important because it promotes critical thinking.” Quote (M7): “Integrating these areas helps promote hands-on learning.”

The abbreviated table (Table3) The training program had a positive impact on most teachers' knowledge of the STEAM methodology. To understand the STEAM concept (C1), 9 teachers moved to a comprehensive practical understanding, while M5 remained at a limited theoretical understanding. Integration between fields (C2) improved for 8 teachers, but M5 and M10 remained at a vague understanding. Teaching methods (C3) developed for 7 teachers to include modern methods, while M5, M9, and M10 remained at limited methods. Awareness of the importance of STEAM (C4) became specific for 9 teachers, with M5 remaining at general awareness.

Detailed table (table4) It shows that teachers relied on informal resources before the program and focused on teaching the material independently. After the program, they demonstrated practical understanding, using applied examples such as integrating science with technology, adopting methods such as problem-based learning, and demonstrating a clear awareness of the benefits of STEAM.

Discussion of results:

The quantitative results showed an increase in the arithmetic mean of the teachers’ scores from 85.92 to 92.69, an increase of 6.77 points (7.9%). The Wilcoxon test confirmed that this difference was statistically significant at the significance level ($\alpha \leq 0.05$), where the value of $Z = -2.803$ at a significance level of 0.005. These results can be interpreted in light of the effective professional development model developed by Desimone (2009), which identifies five key elements: content focus, active learning, consistency, sufficient duration, and group participation. The training program applied in this study appears to have included these elements, as it focused on STEAM methodology content (20 training hours), provided opportunities for practical application (active learning), was linked to the curriculum and school context (consistency), lasted for a sufficient duration (4 days), and included a group of teachers at the same educational level (group participation). A recent meta-analysis by Sims et al. (2023) confirmed that these elements remain effective in enhancing teachers' practices, adding the importance of adapting to local contexts and integrating technology, which is consistent with the use of digital tools such as Padlet, ClassPoint, and Kahoot in the training program of this study within the Jordanian context. This integration of the theoretical framework and recent empirical evidence reflects the effectiveness of the program in achieving statistically significant improvements in teaching practices.

These results are consistent with the study (Subekti et al. (2024) confirmed that vocational training programs that include these elements contribute to transforming teachers' performance and developing their competencies. This is also consistent with the results of Sharaf al-Din's study (2023), which demonstrated the effectiveness of training programs based on the STEM approach in developing teaching performance skills.

Despite the overall quantitative improvement, the qualitative results revealed variations in teachers' responses. For example, the

teacher M5 was the least responsive, while other parameters, such as M1 and M3, showed significant improvement. This integration of quantitative and qualitative data provides a deeper understanding of the phenomenon under study and is in line with recent mixed-methods research trends (Johnson & Onwuegbuzie, 2020).

This discrepancy can be explained in light of constructivist theory which asserts that learners (in this case teachers) construct their knowledge in different ways based on their prior experiences and backgrounds (It can also be interpreted from the perspective of context-based learning theory, where different contextual factors influence teachers’ response to the training program (Juliangkary et al., 2024).

The results of the study are consistent with the studies of Al-Mutairi ((2023), Abu Musa (2021), and Boice et al. (2021) confirmed the effectiveness of training in improving teachers’ practices in the field of STEAM, while differing from the results of Al-Hamouri (2023), which indicated ongoing difficulties in applying STEM despite training, indicating the importance of the institutional context and school environment in supporting educational change.

Discussion of the results of the research question: Improving knowledge of methodology STEAM

The results of the study revealed a significant improvement in the knowledge of most participating teachers regarding the methodology. STEAM, where nine parameters moved from "limited theoretical understanding" to "comprehensive practical understanding." This shift is consistent with the principles of constructivist theory, which emphasizes that knowledge is built through active processes of interaction and application, rather than through passive reception of information (Zin et al., 2024).

Teacher's quote M10: “I have come to understand that STEAM is an approach that integrates materials to solve real-world problems.” This qualitative shift in perception reflects what Nguyen (2025) pointed out about the importance of a deep understanding of the STEAM philosophy as an integrative methodology that goes beyond simply teaching materials separately.

This improvement can be explained in light of the theory of context-based learning (Situated Learning Theory), developed by Lave and Wenger, provided a "community of practice" that enabled teachers to build their knowledge within an applied context. This was confirmed by Juliangkary et al.'s (2024) study, which found that context-based learning enhances teachers' understanding of STEAM methodology by linking theoretical knowledge to real-life situations.

The results are also consistent with Vygotskian principles of learning, as teachers moved from the “zone of actual” to the “zone of proximal development” with the support of training experts and peers, enabling them to develop a deeper understanding of the methodology. STEAM and its practical applications (Makuvire et al., 2025).

Despite the significant improvement in the knowledge of most parameters, the results showed a variance in response, as the parameter did not show M5 improved across various aspects of knowledge. This variation can be explained by four main factors:

Beliefs and preconceived attitudes: The teacher May be M5 holds deeply held beliefs about teaching that are difficult to change, which is in line with Behera et al.'s (2025) study that confirmed that teachers' attitudes significantly influence their response to change.

Institutional context: The teacher May face M5 Institutional constraints limit its ability to apply what it has learned, which is consistent with Al-Faraj's (2024) study, which indicated the importance of ongoing institutional support.

Experience and academic specialization: The teacher's academic specialization may have an impact on her ability to understand the methodology. STEAM, which is in line with the results of Abu Musa's (2021) study on the impact of specialization on teachers' response to training.

Technical skills: The teacher may lack M5 to basic technical skills, which was confirmed by Subekti et al.'s study (2024) that technical skills are a strong indicator of teachers' readiness to adopt the STEAM methodology.

The results of improving teachers' knowledge are consistent with the methodology. STEAM, with Al-Mutairi's study (2023) showing that STEM-based teaching programs contribute to changing teachers' perceptions, and Mehddi et al.'s study (2024) confirming that vocational training enhances teachers' ability to integrate different disciplines.

While the variance in the teachers' response is consistent with the results of Al-Hamouri's study (2023), which indicated that teachers face varying difficulties in implementing the STEM approach, and the study of Afzal and Tandel (2025) which found variation in teachers' readiness to implement STEAM.

Discussion of the results of the second research question: Changing teaching practices

The results of the study showed a noticeable shift in the teaching practices of most female teachers, as they moved from traditional practices to integrative practices based on the methodology. STEAM This shift can be explained through Vygotsky's sociocultural theory, which argues that learning and development occur within social and cultural contexts.

adoption9 project-based lesson planning teachers (P1) reflect their transition from the "actual zone" to the "zone of proximal development" with the support of the training program. This is consistent with Hawari and Noor's (2020) study, which showed that project-based learning enhances the practical application of knowledge by engaging students in projects with tangible goals that integrate various STEAM disciplines.

Teacher's quote M8: "I designed lessons that integrate STEAM, such as a play project about the solar system," reflects the adoption of an "educational authenticity" approach that emphasizes the importance of connecting learning to real-life contexts. This aligns with Abu Musa's (2021) study, which emphasized the importance of project-based learning in developing creative thinking.

The variation in teachers' responses to the teaching practices axes can be explained through the multi-factor framework:

Self-efficacy: Persistent Challenges M5, M9, and M10 in enhancing thinking skills (P6) may reflect low self-efficacy in designing higher-order thinking activities. This is consistent with Behera et al.'s (2025) study, which found that teachers' confidence in their abilities influences their adoption of STEAM.

Educational Context: Classroom Management Challenges (P4) Some teachers may have experienced unsupportive classroom conditions. This is consistent with Afzal and Tandel's (2025) study, which indicated that a lack of resources and infrastructure hinders the implementation of the STEAM methodology.

Curriculum Content: Difficulties in teaching strategies (P2) It may reflect challenges in dealing with curriculum overload. This is consistent with Mehddi et al.'s (2024) study on the impact of curriculum characteristics on STEAM adoption.

Technology: Variation of parameters in technology integration (P5) reflects the different levels of their technical skills. This is consistent with Subekti et al.'s (2024) study, which emphasized the importance of digital competencies in implementing the STEAM methodology.

Transformation in evaluation methods (P3) From "traditional tests" to "performance-based assessment" for 7 teachers is in line with recent trends in educational assessment that emphasize the importance of authentic assessment. This is consistent with what Qablan et al. (2024) indicated regarding the importance of assessing higher-order thinking skills in the context of inquiry-based learning.

Enhance thinking skills (P6) The shift from "memorization-focused" to "systematic, critical thinking-focused" among 7 teachers aligns with the goals of the STEAM methodology for developing 21st-century skills. This is consistent with the study by Al-Omari and Abdul Karim (2024), which found that design thinking contributes to the development of 21st-century skills, and the study by Alkhatib (2025), which emphasized the importance of integrating the arts in promoting creative thinking.

The results of changes in teaching practices are consistent with Sharaf al-Din's study (2023) which demonstrated the effectiveness of training programs in improving teaching performance skills, and the study of Hawari and Noor (2020) which confirmed the importance of project-based learning in enhancing the practical application of knowledge.

It is also consistent with the study. Mehddi et al. (2024) found a significant improvement in interdisciplinary integration after implementing professional development programs, and Al-Subhi (2024) indicated that STEAM implementation contributes to enhancing an active learning environment, while the ongoing challenges are consistent with Afzal and Tandel (2025) who found that lack of resources and infrastructure hinders the implementation of the STEAM methodology, and Al-Hamouri (2023) who indicated that some difficulties persist despite training.

Recommendations:

The study recommends the need to provide an institutional environment that supports the implementation of the methodology.

STEAM through developing educational policies, providing appropriate technical resources and infrastructure, and reducing administrative burdens on teachers, thus ensuring sustainable changes in teaching practices.

-Designing continuous training programs that take into account individual differences.

It is recommended to develop sustainable vocational training programs that consider the differences in experiences, beliefs, and technical skills among female teachers, with a focus on practical training, and support for the building of interactive professional learning communities that contribute to enhancing understanding and effective application of the methodology. STEAM. The study recommends that teachers should be trained to use alternative assessment strategies such as performance-based assessment and assessment of higher-order thinking skills, in line with the objectives of the curriculum. STEAM in developing 21st century skills in students.

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