International Journal of Instruction *January 2024 ● Vol.17, No.1*
e-ISSN: 1308-1470 ● www.e-iji.net *p-ISSN: 1694-609X*
pp. 215-228

Article submission code: 20230216054111
Received: 16/02/2023 Revision: 19/06/2023
Accepted: 12/07/2023 OnlineFirst: 02/10/2023

Availability of STEAM Approach Requirements among Intermediate-Stage Mathematics Teachers and Their Attitudes towards It

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The present research aimed at investigating the availability of the requirements of the STEAM approach among intermediate-stage teachers and their attitudes towards the STEAM approach in public schools of Amman city, Jordan. This was a cross-sectional study that recruited a sample of 294 intermediate-stage mathematics teachers. A researcher-developed questionnaire was used in this study. It comprised 46 items (30 items for the availability of the STEAM approach requirements and 16 items for teachers' attitudes towards the STEAM approach). The data gathered in this study was analyzed using the SPSS. The results showed that the requirements of the STEAM education approach were high. Exploring the domains of STEAM requirements revealed that the implementation domain was the highest available requirement (3.90±0.54), followed by the planning domain (3.81±0.68) was available at a high degree, and lastly the assessment domain (3.11±0.76) at a moderate degree. In addition, the results showed that the enrolled mathematics teachers had positive attitudes toward using the STEAM education approach in teaching mathematics. It was found the most positive attitudes were within the desire to apply the strategy domain (4.18±0.60), followed by the motivation and self-learning domain (4.06±0.83), thinking and problem-solving domain (3.66±1.08) and the last one was collaboration and communication domain (3.21±0.59). The study concluded that STEAM approach requirements are available to a high degree as perceived by intermediate-stage mathematics teachers and they had positive attitudes towards using the STEAM approach in teaching mathematics in the public schools in Amman city, Jordan.

Keywords: STEAM, requirements, attitudes, intermediate stage, mathematics, Jordan

INTRODUCTION

The development of the communication revolution and its means, and the associated rapid spread of knowledge and information, requires the educational institution to achieve more activity and effectiveness, innovation and renewal to keep pace with these changes, and that interest in the development of education is a fundamental goal of its goals (Dell'Era et al., 2020), and amid development, which is one of the features of the

Citation: Alfayez, M. Q. E. (2024). Availability of STEAM approach requirements among intermediate-stage mathematics teachers and their attitudes towards it. *International Journal of Instruction*, *17*(1), 215-228. https://doi.org/10.29333/iji.2024.17112a

third millennium, attention is directed towards the educational systems, represented by its various institutions, to assume its responsibilities towards the learners according to an educational perspective based on its development and liberation of its creative energies (Lueddeke, 2020).

Several scientific research indicated the role played by teaching strategies based on integration and linking the teaching of mathematics in improving the quality of teaching, and in activating students' roles in situations of using objects for achievement and communication, and enhancing the pivotal and integrative role of science and mathematics curricula (Kelley & Knowles, 2016). Modern education also emphasized the need to pay attention to modernizing education strategies to improve all aspects that are beneficial to the learner and enable him/her to adapt to the requirements of the current century and deal with its events, knowledge openings, and technical innovations, by transferring the learner from the role of the recipient to the role of the participant and creator (Mirzaxolmatovna et al., 2022).

The use of a variety of modern teaching-learning strategies contributes to the development of the learner's thinking and the acquisition of facts, information, and concepts, and adds educational activities that make his learning meaningful and understandable, not just memorizing information (Magen-Nagar & Cohen, 2017).

Scientific educational fields have also tended to show the approach of science, technology, engineering, and mathematics as a multidisciplinary approach capable of integrating the content and skills of science, technology, engineering, and mathematics, and can develop problem-solving within realistic, practical contexts through related projects in which students simulate what scientists practice (Ntemngwa & Oliver, 2018).

The STEAM project appeared in the United States of America within the economic and scientific aspects, facing the challenges faced by students, and preparing them for the post-study stage, to make them more capable of solving problems and facing the challenges of the times, most important of which is the skills and experience that the individual possesses that are necessary for the labor market (Quigley & Herro, 2016; Yoh et al., 2022).

The STEAM approach to education has gained significant recognition over the years due to its integrative, multidisciplinary nature that fosters problem-solving and real-world applicability. It brings together the rigor of scientific and mathematical principles with the creative process inherent in the arts, providing an all-encompassing learning experience for students. STEAM education is considered vital in the 21st-century educational landscape due to its potential to stimulate innovative and critical thinking, preparing students for a diverse and rapidly changing workforce (Herro & Quigley, 2017). This approach's importance is further magnified in light of the increasing demand for STEM professionals with a well-rounded, adaptable skillset that encompasses not only technical acumen but also creative and collaborative capacities.

In particular, the attitudes of mathematics teachers toward the STEAM approach play a crucial role in its successful implementation. Teachers serve as the conduits of educational change, and their attitudes towards novel pedagogical methods can

significantly influence their readiness to adopt these methods and their effectiveness in employing them (Kim, Park, & Yoon, 2018). With mathematics being a central component of the STEAM approach, mathematics teachers' attitudes towards this approach can greatly impact student learning outcomes. A positive attitude can enhance the instructional process, inspiring students to engage more deeply in mathematical exploration and problem-solving within a broader, interdisciplinary context. Furthermore, when mathematics teachers demonstrate a positive attitude and readiness towards the STEAM approach, it not only enhances their teaching efficacy but also contributes to improved student motivation, interest, and achievement in mathematics, underscoring the importance of fostering such attitudes in teachers.

Thus, the curricula and textbooks within the Ministry of Education, especially mathematics books, sought to achieve many axes, including the ability of students to understand the nature of science and employ the scientific methodology to be able to solve scientific questions, and life problems they face, in addition to its ability to link scientific knowledge to life, and his ability to realize the importance of mathematics in life and technological applications

In light of the previous introduction, the researcher hopes that this study will identify the availability of STEAM approach requirements and attitudes towards it among a sample of Jordanian intermediate-stage mathematics teachers.

Statement of problem

The profession of teaching mathematics is not merely conveying what is included in the mathematics curriculum to the learners, but rather it is a cumulative construction of emotional and social information and skills (Singer et al., 2016), as the teacher's job is to teach the learner how to think and apply what he has learned in life and to use the information he has obtained in solving problems he/she encounters, as well as It is about developing a love for mathematics, interpreting its laws, and instilling a love for science and scientists in the learner through his love for the teacher and the method followed by the teacher (Knowles et al., 2018).

Mathematics teachers still follow teaching methods and methods that depend on deaf memorization and memorization. Thus, in this case, the teacher is the focus of the educational process, and the learner is the recipient of information and skills, and thus his/her role becomes negative, which leads to his feeling of boredom and lack of interest in the lesson (Kennedy, 2016). Through our experiences in educational supervision and observation of various teachers, we have noticed a potential limitation in the effectiveness of conventional teaching methods in raising students' academic achievement. This observation is aligned with a body of research suggesting that traditional, lecture-based instruction may not be as effective in promoting deep learning and critical thinking skills as more interactive, student-centered methods (Prince, 2004; Freeman et al., 2014).

As a solution to this perceived issue, there has been a growing interest in the educational community to find and utilize more effective teaching methods, one of which is the STEAM approach. The STEAM approach, which integrates Science, Technology,

Engineering, Arts, and Mathematics, has been touted for its potential to elevate student achievement. This is because it fosters problem-solving skills, critical thinking, and creativity through an interdisciplinary approach (Herro & Quigley, 2017; Quigley & Herro, 2016). These skills are not only crucial for academic success but also for students' ability to apply their knowledge effectively in real-world situations (Johnson, 2012). Consequently, this study investigates the availability of STEAM approach requirements among intermediate-stage mathematics teachers and their attitudes towards it.

Also, the methods and teaching methods used do not provide an opportunity for learners to practice most of the activities themselves, as mathematics is an applied experimental science and it is one of the important scientific subjects closely related to human life, in which learners find it difficult to learn its concepts. It is important in the theoretical aspect without the practical aspect, for the continuation of subsequent education, especially concerning mathematics, as this subject contains many concepts, which are among the basic concepts that pave the way for the subsequent stages. Therefore, teachers should be urged to use modern teaching models and methods in teaching mathematics that helps in acquiring mathematical information. And raise academic achievement. In light of the above, it was necessary to use modern strategies. Therefore, the current study aims to identify the availability of the requirements of the STEAM approach in teaching mathematics and what are the attitudes of middle school mathematics teachers towards it.

Research Significance

The importance of the current study is represented by its theoretical and practical importance. Its practical importance is represented in helping teachers of mathematics to learn about the STEAM approach in the educational process and changing the usual method of teaching to increase the effectiveness of teaching and provide a clear vision. Teaching, and changing the roles of the teacher and the learner in the educational learning process.

Its importance is also represented in giving a picture to those in charge of mathematics curricula and methods of teaching it in the study community about the extent to which the school adopts this important approach in teaching mathematics, and working to enlighten mathematics teachers with some practical measures in implementing mathematical skills based on the concept of the STEAM approach. The results of the study drew the attention of those in charge of developing science curricula, especially in mathematics, in Jordan, to take this approach to develop strategies for teaching mathematics.

The theoretical importance is that it may be benefited the workers in the Ministry of Education in Jordan, including teachers and supervisors, by knowing the impact of STEAM teaching on the development of achievement in mathematics among teachers of mathematics. It may contribute to providing a vision for subsequent studies that can be used to develop the degree of employment of science learning approaches for mathematics teachers.

Research Definitions

STEAM approach: Studying the natural world as it is, and analyzing its relationships to reach the laws of nature associated with it, whether components related to physics, chemistry, biology, geoscience, arts, and humanities, or mathematics, to address or apply the facts and principles associated with these disciplines (Liao, 2016).

Mutakinati et al., (2018) believe that it is an educational system based on research and thinking, problem-solving, and education through projects, through which students apply what they learn in science, mathematics, and engineering using technology, an approach based on merging concepts with reality, through practical application. These concepts, as these materials are learned in a logical sequence, and the learning of these materials are based on each other, and linked to real applications in which the student lives. The approach combines in various ways the four major disciplines: science, technology, engineering, and mathematics.

It is defined procedurally as employing problem-solving, inquiry, and project-learning strategies in teaching mathematics subjects to middle school students.

Attitudes can be defined as a complex interplay of beliefs, feelings, and actions towards a particular object, person, or situation. According to Maio and Haddock (2010), attitudes "represent individuals' positive or negative evaluations of an object." These evaluations can be expressed cognitively (through thoughts and beliefs), affectively (through feelings and emotions), and behaviorally (through actions and behavioral intentions).

Teachers can be defined as professionals who provide instruction, guidance, and assessment for students in various stages of learning, facilitating their intellectual and social development. They are crucial actors in the educational system, tasked with delivering curriculum content, fostering a positive learning environment, and nurturing students' critical thinking and problem-solving skills (OECD, 2005).

Procedurally, for the purpose of this study, teachers are defined as intermediate-stage teachers in the city of Amman, Jordan. These are professionals who teach students generally between the ages of 12-15 (typically grades 7-9), helping them navigate an important transitional phase from primary to secondary education. They provide instruction in various subjects, including mathematics, and are responsible for applying and adapting national curriculum requirements to meet the diverse needs of their students. In the context of this research, our focus is specifically on these intermediate-stage mathematics teachers' preparedness for, and attitudes towards, the STEAM approach.

Previous Studies

Al-Qarni (2018) conducted a study aimed at building a proposed training program for the development of professional competencies among faculty members in scientific colleges at the University of Bisha in light of the requirements of the entrance to the integration between science, technology, and engineering STEM. There were 58

competencies distributed within 6 axes that were used in preparing a questionnaire to determine the training needs of teachers of scientific colleges.

Al-Shammari (2018) conducted a study aimed at examining the effectiveness of an enrichment program based on the STEM curriculum in developing the skills of mathematical strength among gifted female students in the intermediate stage in the city of Hail. The researcher used the semi-experimental approach, that is, the one-group design; Where the study was conducted on a sample of 30 female students, the study tool, which is the mathematical strength test, was applied in two applications, pre, and post, and the results showed that there were statistically significant differences between the pre and post applications in favor of the post, which means the effectiveness of the enrichment program designed according to the STEM approach in developing the skills of mathematical strength

As for Al-Maliki (2018), the study aimed to identify the effectiveness of teaching science in the environmental systems unit according to the STEM approach in developing scientific research skills according to the standards of the IntelISEF model among fifth-grade students in Jeddah. Each group included 35, and the scientific research skills test was used in the measurement with two applications: pre and post, and the study concluded that there were statistically significant differences between the mean scores of the students of the experimental group and those of the control group in the post application of the test of scientific research skills according to the criteria of the IntellSEF model in favor of the experimental group.

The study by Abu Musa (2019) aimed at revealing the effectiveness of a unit in science designed according to the STEM integrative approach in developing scientific practices among ninth-grade students. The study included materials and tools for analyzing the content of the target unit according to the dimensions of STEM, the proposed unit, the teacher's guide to implementing the teaching of the unit, a list of scientific practices, ninth-grade students, a note card for scientific practices, the study was conducted on 40 students from Taiba Secondary School for Girls, Directorate of Education east of Khan Yunis, the results of the study showed that there are statistically significant differences at the level of significance (0.01) between the average degrees of scientific practices in the pre and post applications of the observation card, and that teaching science according to the STEM approach has a significant impact on ninth-grade students.

The thorough review of the literature revealed a significant lack of studies exploring the requirements of the STEAM education approach. The researchers observed that the previous studies focused on the STEM approach. Therefore, this study would significantly contribute to the literature by exploring the newly released approach.

METHOD

Research design

In the current study, we utilized a quantitative cross-sectional research design. This design allowed us to capture a snapshot of attitudes and preparedness among intermediate-stage mathematics teachers in Amman, Jordan, at a single point in time.

Given the nature of the research questions and the design of the study, we used predetermined categorizations to structure our data collection and analysis process

Research population

The population of the study is represented by all mathematics teachers of the intermediate stage who are working in public schools in Amman city, Jordan. According to the statistics released by the Jordanian Ministry of Education (MoE), the number of intermediate-stage mathematics teachers is 1242 teachers distributed over more than 1160 public schools (morning and evening shifts).

Research Sample

The study sample consisted of 294 mathematics teachers. The convenient sampling method was used to recruit the study participants. The sample size was calculated using a confidence interval of 95%, a margin of error of 5%, and a response distribution of 50%. Convenience sampling is a non-probability sampling method in which samples are selected from the study population only because they are available to the researcher, these samples are chosen only because of the ease of their use by the researcher and that the researcher did not take into account the selection of samples that represent the entire study population. Convenience sampling was chosen for this study for several reasons. Primarily, it offers practicality and efficiency as this method requires less time and resources compared to other sampling techniques, making it a practical choice for initial exploratory studies like this one. Further, convenience sampling allows for easy accessibility to the population which in this case is the mathematics teachers in the intermediate stage in Amman, Jordan.

Research Instrument

The researcher developed a study questionnaire to explore the availability of the STEAM education approach in teaching mathematics to intermediate-stage students and teachers' attitudes towards it. The questionnaire was built based on literature, previous empirical studies, and other data collection instruments used in previous studies.

The first part of the study questionnaire aimed to identify the availability of the requirements of the STEAM education approach among intermediate-stage mathematics teachers. It consisted of three domains: Planning, Implementation, and assessment. The planning domain consisted of 12 items, whereas the implementation and assessment domain consisted of 9 items for each. The 5-point Likert scale was used to scale the questionnaire items as follows: very high (5), high (4), moderate (3), low (2), and very low (1). The levels of availability were calculated as follows: low availability (1.00 – less than 2.33), moderately available (2.33 – less than 3.66), and high availability (3.66 – 5.00).

The second part of the study questionnaire aimed to identify the intermediate-stage teachers' attitudes toward using the STEAM education approach in teaching mathematics to intermediate-stage students. The questionnaire consisted of 16 items distributed over 4 domains as follows: the desire to apply the strategy, thinking and problem solving, motivation and self-learning, and collaboration and communication.

The planning domain assessed the teachers' ability to create interdisciplinary lesson plans that incorporate all elements of the STEAM approach. Indicators in this domain included the ability to identify clear, achievable objectives that align with STEAM principles, select appropriate resources, and integrate various STEAM disciplines into a cohesive lesson plan.

The implementation domain focused on the teachers' ability to effectively deliver the STEAM lesson in the classroom. Indicators in this domain included the use of hands-on, inquiry-based learning methods; facilitation of collaborative, problem-solving activities; and integration of technology and real-world connections into the lesson delivery.

Finally, the assessment domain measured the teachers' use of diverse assessment strategies that align with the STEAM approach. Indicators here included the use of formative and summative assessments, project-based assessments, and the ability to provide constructive feedback that encourages students' creativity and critical thinking skills.

To ensure the validity of the study questionnaire, the research submitted the primary version of the study questionnaire to many experts and specialized academic staff in mathematics teaching, mathematics curriculum design and development, and three mathematics teachers. The researcher kindly asked them to review the study questionnaire and provide their opinions regarding the content of the questionnaire items, the appropriateness to answer the study questions, and the linguistic aspects. The proposed amendments were done and a number of items were reformulated to improve their reporting.

To ensure the reliability of the study questionnaire in its two parts, each part was administered to a pilot sample of 30 intermediate-stage mathematics teachers, who were excluded from the original study sample. The Cronbach's Alpha equation was used to assess the reliability of the study questionnaire. In the first part, a reliability coefficient of 0.73, 0.81, and 0.76 were obtained for the planning, implementation, and assessment domains. The total reliability coefficient was 0.77. On the other hand, the reliability coefficient of the second part, which was the attitudes scale, was 0.79, 0.77, 0.81, 0.79 for the desire to apply the strategy, thinking and problem-solving, motivation and self-learning, and collaboration and communication domains, respectively. The total reliability score was 0.77.

Data collection procedure

The data collection process started with preparing the questionnaire package and attaching a consent form. The researchers visited the intermediate-stage schools in Amman city and distributed the study questionnaire to the intermediate-stage mathematics teachers. The researchers provided the mathematics teachers with a brief introduction to the study, its aims, and its significance of the study. The mathematics teachers were asked to fill in the study questionnaire and return the filled questionnaire to the researcher or drop it in a specific box at the administration office. Complete and valid questionnaires were used in the data analysis process.

Data analysis

To analyze data, we used the Statistical Package of Social Sciences (SPSS) (v. 26, IBM Corp, Chicago, IL, USA). The Cronbach's alpha equation was used to assess the reliability of the study questionnaire. In addition, descriptive statistics; frequencies, percentages, means, and standard deviations were used to analyze the study participants' responses and answer the research questions.

FINDINGS

A total of 294 intermediate-stage mathematics teachers were enrolled in this study. The results shown in table (1) represent the participating mathematics teachers' sociodemographic characteristics. The results showed that the mean age of the enrolled teachers was (39.2±3.10). Females constituted 35% (n=103) of the enrolled teachers, whereas male mathematics teachers were representing 65% (n=191). Concerning years of experience, it was found that 27.6% (n=81) had less than 5 years of experience, 40.8% (n=120) had 5 to 10 years of experience and about 31.6% (n=93) had more than 10 years of experience.

Table 1
Baseline characteristics of the enrolled mathematics teachers

Variable	F (%)	M (SD)
Age		39.2 (3.10)
Gender		
1. Male	191 (65)	
2. Female	103 (35)	
Years of experience		0.58
1. Less than 5 years	81 (27.6)	
2. 5 – 10 years	120 (40.8)	
3. More than 10 years	93 (31.6)	

The results presented in table (2) show the mean scores and standard deviation for the enrolled mathematics teachers' responses on the questionnaire domains measuring the availability of the requirements of the STEAM education approach. The results showed that the requirements of the STEAM education approach were high. Exploring the domains of STEAM requirements revealed that the implementation domain was the highest available requirement (3.90±0.54), followed by the planning domain (3.81±0.68) was available at a high degree, and lastly the assessment domain (3.11±0.76) at a moderate degree.

Table 2
Means and Standard Deviations of the enrolled mathematics teachers' responses to the availability of the requirements of the STEAM education approach

Domain	M±SD	Degree	Rank
Planning	3.81±0.68	High	2
Implementation	3.90±0.54	High	1
Assessment	3.11±0.76	Moderate	3
Total	3.66±0.66	High	

The results presented in table (3) show the mean scores and standard deviation for the enrolled mathematics teachers' responses on the questionnaire domains exploring their attitudes towards using the STEAM education approach. The results showed that the enrolled mathematics teachers had positive attitudes towards using the STEAM education approach in teaching mathematics. It was found the most positive attitudes were within the desire to apply the strategy domain (4.18±0.60), followed by the motivation and self-learning domain (4.06±0.83), thinking and problem-solving domain (3.66±1.08), and the last one was collaboration and communication domain (3.21±0.59).

Table 3
Means and Standard Deviations of the enrolled mathematics teachers' attitudes towards using STEAM education approach

Domain	M±SD	Degree	Rank
Desire to apply the strategy	4.18±0.60	Positive	1
thinking and problem solving	3.66±1.08	Positive	3
motivation and self-learning	4.06±0.83	Positive	2
collaboration and communication	3.21±0.59	Moderate	4
Total	3.81±0.70	High	

DISCUSSION

The STEAM philosophy converges five fundamental fields, namely Science, Technology, Engineering, Arts / Humanities, and Mathematics, forming a comprehensive educational system. This pedagogy, accentuating problem-based learning and real-life projects, resonates with Drake and Burns' (2004) interdisciplinary teaching theories. Given the interdisciplinary nature of 21st-century tasks and innovations, implementing STEAM education in classrooms requires cross-curricular cooperation, underlining the tangible value of the STEAM approach.

In our study, we noted a significant readiness for the STEAM education approach among intermediate-stage mathematics teachers in Amman, Jordan. These results coincide with Herro and Quigley's (2017) findings, which emphasized the growing readiness for STEAM education among teachers worldwide. Such positive outcomes can be traced back to the robust efforts by the Jordanian Ministry of Education to enhance the capacities of mathematics teachers. These capacity-building strategies are reminiscent of Piaget's (1973) and Vygotsky's (1978) constructivist learning theories, endorsing the notion of active knowledge construction through experiential learning.

Furthermore, our study revealed that the intermediate-stage mathematics teachers in Jordan showed positive attitudes toward implementing the STEAM approach in teaching mathematics. This parallels the findings of Kim, Park, and Yoon's (2018) study, which reported a favorable attitude among teachers toward the STEAM approach. STEAM education, by its nature, advocates for students to work in collaborative teams, promoting deeper understanding across various disciplines. This strategy transforms teachers into facilitators, enhancing student engagement, aligning with Johnson and Johnson's (1999) collaborative learning theory.

Despite the robustness of our study, it did carry certain limitations. Primarily, it only involved intermediate-stage mathematics teachers and did not include teachers from other educational stages. Additionally, it was restricted to public schools in Amman, excluding private schools or schools in different geographical regions within Jordan.

Subsequent research should address these gaps and continue exploring the implementation of STEAM education in diverse educational contexts. Nonetheless, our study provides valuable insights into the readiness and attitudes of intermediate-stage mathematics teachers towards the STEAM approach, paving the way for further enhancements in interdisciplinary education.

Research Contribution

This research contributes significantly to the literature on the STEAM approach in education, specifically focusing on the preparedness and attitudes of mathematics teachers towards it. Our study, situated in Amman, Jordan, presents an insightful examination of the degree to which mathematics teachers are equipped with the necessary skills and knowledge for implementing the STEAM approach, a topic hitherto underexplored in this region. By assessing the readiness of these educators and their attitudes towards the approach, we have illuminated potential areas for further professional development and policy initiatives aimed at promoting STEAM education. Moreover, this research could serve as a model for similar investigations in other regions or other subject areas, helping to create a more comprehensive global understanding of the factors influencing the successful implementation of STEAM education. Ultimately, our study underscores the importance of teachers' attitudes and readiness in driving educational change and provides valuable insights that may guide the ongoing efforts to advance integrative, multidisciplinary education.

CONCLUSION AND RECOMMENDATIONS

The study concluded that intermediate-stage mathematics teachers reported high availability of the STEAM education approach in public schools in Amman city, Jordan. In addition, the study concluded that intermediate-stage mathematics teachers had positive attitudes toward using the STEAM education approach in teaching mathematics. Based on the findings of this study, the study recommends providing continuous professional development workshops to intermediate-stage mathematics teachers in Jordan and expanding the content of these workshops to include experiences from regional and international regions and schools. In addition, this study recommends conducting further cross-sectional studies that address the same study variables but include a larger sample size from different educational stages and different geographical zones in Jordan.

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