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UPPER-SECONDARY SCHOOL SCIENCE TEACHERS' PERCEPTIONS OF THE INTEGRATING MECHANISMS AND IMPORTANCE OF STEM EDUCATION

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Abstract. *This study aimed to recognize upper-secondary school science teachers' perceptions of the meaning, importance, and integrating mechanisms of science, technology, engineering, math (STEM) education, taking in to account the differences between the science teachers' perceptions according to their specialties, years of experience, and degrees. A closed-ended questionnaire was distributed among 700 science teachers (biology, physics, and chemistry) in Riyadh, and 255 teachers responded. The results showed a strong alignment in the upper-secondary school science teachers' perceptions of the meaning and the importance of STEM education, although there was less of a consensus regarding the integrating mechanisms. There were statistically significant differences in the physics teachers' perceptions of STEM meaning, although there were otherwise no significant differences by specialty in the science teachers' perceptions of the importance of STEM education and its integration mechanisms. Furthermore, the teachers showed no statistically significant differences in STEM's meaning, importance, or integrating mechanisms according to their years of experience. Based on the results, recommendations included intensifying professional development programs on utilizing technology, engineering, and mathematics in learning science concepts and application.*

Keywords: *integration mechanisms, science teachers, STEM education, teachers' perceptions, upper secondary school*

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Introduction

The science curriculum is considered one of the pillars of scientific and technological progress; it contributes to developing learners' knowledge and applied skills as well as expanding on science trends. However, there is a gap between what is taught in schools and what students need in their lives and to succeed in the job market. One means of addressing this gap in learning is taking advantage of global visions and experiences in science education.

Because of the natural overlap between science, technology, engineering, and mathematics, science curricula have evolved to reflect the relationships among the fields. In the 1990s in the United States, the National Science Foundation created a consolidated science, technology, engineering and mathematics (STEM) education topic to expand the skilled and innovative workforce by enhancing students' ability to build and produce science knowledge across the four integrated fields (Misher, 2014).

A committee that consisted of the National Academy of Engineering and the National Research Council (NAE & NRC, 2014) defined science as studying and investigating the natural worlds, mathematics as studying relationships between quantities to build logical arguments, engineering as knowledge about design and product construction, and technology as knowledge, processes, and tools that relate to employing and producing technology. The mechanisms of integrating these fields vary because of differing educational strategies and different special features across fields (NAE & NRC, 2014). For instance, some curricula might aim to teach science, technology, engineering, and mathematics integrally, while others might incorporate some aspects of the STEM fields to support teaching other fields (Bybee, 2013).

However, what best facilitates the integration of the STEM fields into teaching is focusing on major ideas, for example, connecting a problem or a concept to learners' realities (Mcgehee, 2015). The Next Generation Science Standards (NGSS) were developed to reflect this enhanced understanding of science and engineering practices so as to build on learners' knowledge through a variety of practices. Specifically, the new standards aimed to clarify

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how to accomplish the following: define problems and ask questions, develop and use models, plan and conduct investigations, analyze and interpret data, use mathematics and computational thinking, interpret findings and design solutions, and generally participate in science debate based on obtaining, analyzing, interpreting, and communicating evidence (NRC, 2012).

Several researchers have identified positive impacts of teaching in accordance with STEM education on forming positive attitudes toward STEM (Laforce et al., 2017; Lou et al., 2010; Misher, 2014), improving academic achievement (Al-Qathami, 2017; Al-Shehimiah, 2015; Najjar, 2015; Wahono et al., 2020), and developing 21st-century skills (Husin et al., 2016), thinking habits (Al-Daoud, 2017; Najjar, 2015), thinking skills (Al-Qathami, 2017), decision-making skills (Al-Daoud, 2017; Rizk, 2015), creative thinking (Al-Shehimiah, 2015), and motivation (Wahono et al., 2020). Given the importance of STEM education and its reliance on teachers' understanding and attitudes toward it (NAE & NRC, 2014), recognizing teachers' perceptions of STEM education could contribute to helping them organize their knowledge and understand their behaviors (Owens, 2014; Turner, 2013).

The global interest in STEM education is evident as it is included in 798 articles in 36 journals during the period of 2000 to 2018. However, the topics related to teacher and STEM teaching of K-12 comprised 12.9% (Li et al., 2020), and this may highlight the need for more research on teachers, particularly their perceptions, of what notions contribute to guiding teaching decisions (Shahzad et al., 2017). Some local and international studies that were conducted on science teachers' perceptions of STEM education have shown positive perceptions of the STEM concept (Al-Anzi and Al-Jabr, 2017; Ambosaidi et al., 2015; Smith et al., 2015), and its importance (Amir et al., 2015; Park, et al., 2016; Turner, 2013; Wang, 2012). These results were revealed after teachers had received training courses on STEM education for 8 hours, as the study of Amir et al. (2015), or 3 weeks, as the Turner's (2013) study, or a year and a half, as Wang's (2012) study. On the other hand, the studies of Al-Anzi and Al-Jabr (2017) and Ambosaidi et al. (2015) revealed the perceptions of Science educators about the concept of STEM education and its teaching requirements prior to the enrollment in professional development programs about STEM.

Several studies have revealed the relationship between teachers' perceptions of STEM education and some variables. The first variable is teaching practices, such as the studies of Owens (2014) and Wang (2012), which made it clear that teachers' perceptions appeared clearly in their teaching practices when they were observed in the classroom. The second variable is years of experience, such as the study of Al-Anzi and Al-Jabr (2017), Park et al. (2016), Ambosaidi et al. (2015), and Smith et al. (2015), whose results did not show statistically significant differences in teachers' perceptions of STEM that attributed to their years of experience. However, the study of Park et al. (2016) showed statistically significant differences in teachers with more than 15 years of experience. The third variable is gender. The study of Park et al. (2016), Ambosaidi et al. (2015), and Smith et al. (2015) showed statistically significant differences in teachers' perceptions of STEM for male teachers. The fourth variable is educational stages. The studies of Al-Anzi and Al-Jabr (2017) and Park et al. (2016) showed statistically significant differences in the teachers' perceptions of STEM which were found in favor of elementary school teachers.

Changing perceptions is difficult and may take a long time as it has gone through several stages: "awareness, development of interest, mental experimentation, actual experimentation, then adoption or rejection" (Al-Saleh, 2002, p. 10). Thus, this study aimed to know the perceptions of science teachers before applying STEM education in schools, or before joining professional development. It may give results that would contribute to guiding professional development programs. With a careful extrapolation of the previous studies, it becomes clear that there are no local studies that have dealt with the perceptions of science teachers at the secondary level about the concept, importance, and mechanisms of STEM education.

Research Problem

Scholars in Saudi Arabia have identified challenges to incorporating technology and engineering into science textbooks. Efforts have focused on the theoretical aspect of technology and its role in science research more than on engineering design or on connecting technology to science problems in society (Al-Ahmad & Al-Buqami, 2017; Al-Beez, 2017; Al-Hamidani, 2017; Al-Ahmadi, 2016); moreover, the natural sciences are rarely integrated (Al-Beez, 2017; Al-Hamidani, 2017). These shortcomings could negatively affect learners' understanding of science concepts or their abilities to face scientific problems and solve them. Learners in the Trends of the International Mathematics and Science Studies (TIMSS, 2019) performed below the average (Al-Shamrani et al., 2016).

One of the supporting steps of the transformation to a more productive society that can confront problems related to science is keeping up with new trends in science education such as STEM education. The interest in this

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trend was reflected in newly established science centers and STEM education conferences, but despite the interest in applying STEM education, there are some challenges. In particular, STEM education tends not to be included in teacher preparation courses, and many districts in Saudi Arabia have large numbers of schools and teachers (Al-Dossary, 2015). Al-Daoud (2017) recommended identifying science teachers' perceptions about this trend, and Al-Anzi and Al-Jabr (2017) conducted a study to do so; specifically, they studied science teachers' perceptions of STEM education teaching requirements. However, no researchers in Saudi Arabia have examined the meanings and importance of STEM for science teachers or their perceptions of integrating mechanisms. This study aimed to fill that research gap with a focus on whether science teachers' perceptions varied according to their years of experience, field of specialization, or academic degree.

Research Questions

1. What are upper-secondary school science teachers' perceptions of STEM education in terms of its concept, integrating mechanisms, and importance?
2. Are there any statistically significant differences ($\alpha \leq .05$) among upper-secondary school science teachers' perceptions of STEM education by specialization?
3. Are there any statistically significant differences ($\alpha \leq .05$) among upper-secondary school science teachers' perceptions of STEM education by years of experience?
4. Are there any statistically significant differences ($\alpha \leq .05$) among upper-secondary school science teachers' perceptions of STEM education by academic degree?

Research Significance

1. This study responds to recent trends in science education.
2. The value and importance of science teachers' voices in improving science education by identifying science teachers' perceptions of STEM education as previous studies assured (Owens, 2014; Shahzad et al., 2017; Wang, 2012).
3. The results could help in designing professional development programs that meet the needs of science teachers.

Research Terms

Perception is a mental process that enables individuals to construct ideas, opinions, or concepts based on their personal experiences, feelings, and needs, and teachers' perceptions have a recognized effect on their classroom actions (Choy & Cheah, 2009). Practically, perception in this study refers to science teachers' opinions about the importance of STEM education and the mechanisms of integrating different STEM concepts as well as the influence of their perceptions on their teaching performance.

STEM education refers to curricula that attempt to integrate science, technology, engineering, and mathematics into one category based on the connections in the natural world (Stohlmann et al., 2012). For this study, STEM education refers to instruction methods that enhance learners' holistic understanding and utilization of STEM concepts and practices.

Integrating mechanisms refer to methods and forms of integrating science, technology, engineering, and mathematics (Bybee, 2013). Mechanisms of integrating the different topics can vary according to the specificity of academic subjects or the diversity of educational strategies (NAE & NRC, 2014) and depend on the learning context, how science content is organized, and who is teaching.

Research Methodology

General Background

For this descriptive study, the researchers used a questionnaire, a tool with which "all members of the research community, or a large sample of them, are questioned to describe the studied phenomenon, in terms of its nature, and the degree of its existence, without going beyond that to study the relationship or deduce the causes" (Al-

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Assaf, 2016, p. 211). A survey was the most appropriate approach for collecting, describing, and interpreting the data on science teachers' perceptions of STEM education. The study was applied during the academic year 2018. And it was limited to girls' public and private upper-secondary schools in the city of Riyadh due to the separation between girls and boys in Saudi schools.

Population and Participants

According to the statistics of the Riyadh Education Department (2017), the population included 1,754 upper-secondary school science teachers from private and public schools in Riyadh, Saudi Arabia. A sample of 700 upper-secondary school science teachers was chosen from the population through stratified sampling based on science specialization. To ensure that the study takes into account the ethics of scientific research, a brief description of the study objectives, procedures, and tools has been sent to the Scientific Research Ethics Committee at King Saud University to get their permission. The research objectives have been clarified for the sample in the tool, and it is assured that they observe the confidentiality of their data. It was also ensured that the letter sent by the Ministry of Education to science teachers did not include any mandatory formula to answer the questionnaire. The information and the questionnaire were sent by the Information Technology Department at the Ministry of Education to the sample via text messages. However, although the sample comprised 40% of the population, only 255 teachers responded, accounting for approximately 15% of the population; the sample consisted of 92 biology teachers, 78 physics teachers, and 85 chemistry teachers. In terms of their years of experience, 7% of the teachers had been teaching for less than five years, 27% had between five and 10 years of experience, and 66% had taught for more than 10 years. By academic degree, 86% of the teachers in this study held a bachelor's degree, 14% held a master's degree, and only one held a doctorate. All members of the sample were female.

Instrument and Procedures

The questionnaire consisted of two parts. The first part asked the respondents about their years of experience, specialties (biology, physics, and chemistry), and academic degree; the second part had three sections: STEM meaning, importance, and mechanisms for integrating. The number of items in each section was 13 in STEM meaning, seven items in mechanism for integrating, and eight items in importance. These items reflected the scientific visions of the NEA and NRC (2014) and Bybee's (2013) integrating mechanisms. The participants rated each questionnaire item on 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, and 5 = strongly agree). The researchers then divided the responses into one of four categories: high, medium, low, and very low.

Reliability and Validity

The researchers validated the questionnaire by presenting it to a group of experts in curriculum and instruction and calculated the internal consistency reliability using Pearson's correlation coefficient. The results ranged between .985 and .609, which indicated that each questionnaire item had a medium to high internal correlation and, thus, confirmed the reliability for implementation (Abu Hashem, 2012). Moreover, the researchers administered the questionnaire to a pilot sample that comprised 30 upper-secondary school science teachers and calculated a Cronbach's alpha of .983, which reflected a high reliability (Allam, 2007).

Data Analysis

Various statistical methods were used to analyze the data. Descriptive statistics included frequencies (mean and standard deviations) of each item of the questionnaire were calculated to find science teachers' perceptions of STEM education. One-way analysis of variance (ANOVA) was conducted to find the differences in science teachers' perceptions of STEM education according to their years of experience and specialization (biology, physics, chemistry). Scheffe's test for post-hoc comparisons was used to distinguish the teachers' differing perceptions according to their experience and specialties. A t-test was used to detect differences in science teachers' perceptions of STEM education according to their academic degrees.

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Research Results

The findings for the first study question, on upper-secondary school science teachers' perceptions of STEM education, revealed strong agreement in the teachers' perceptions of the meaning of STEM (M = 4.26). Specifically, the two most commonly selected STEM meanings were "connecting learning scientific concepts with issues and problems of the natural world" and "preparing a stimulating learning environment to show students' correct and incorrect concepts and discussing them." In contrast, the two lowest-ranked STEM meanings are "employing simulation software to build predictions about the engineering design performance related to scientific concepts" and "developing students' engineering practices, such as creating or drawing engineering designs, then evaluating and developing them to understand or solve scientific problems" (see Table 1).

Table 1
Means and Standard Deviations of Science Teachers' Perceptions of STEM Meaning

Item	*M*	*SD*	Ranking
STEM education meaning			
3. Connecting learning scientific concepts with issues and problems of the natural world related to environment, energy, health, climate change.	4.41	0.651	1
11. Preparing a stimulating learning environment to show students correct and incorrect concepts and discussing them.	4.40	0.762	2
12. Preparing a motivating learning environment to generate students' questions.	4.40	0.766	3
13. Prepare a stimulating learning environment for students to evaluate each other's ideas based on evidence and arguments.	4.35	0.784	4
9. Engaging students in realistic experiences in which they employ science, technology, engineering, and math concepts and practices.	4.34	0.674	5
10. Directing the students to determine scientific problems, design and propose solutions, and perform implementation, interpretation and analysis by themselves.	4.32	0.725	6
5. Students' employing technology to build or apply their scientific knowledge.	4.31	0.666	7
6. Employing technologies to support dialog and communication between students, researchers, and scholars.	4.31	0.739	8
2. Students learn science concepts in the light of science phenomena or problems in ways that integrates the related scientific disciplines.	4.21	0.794	9
7. Students use mathematical models to build scientific explanations or engineering designs.	4.16	0.711	10
1. Lessons are structured in the form of key concepts that connect science, technology, engineering, and mathematics.	4.16	0.713	11
8. Employing simulation software to build predictions about engineering design performance related to science concepts.	4.11	0.789	12
4. Developing students' engineering practices, such as creating or drawing designs, evaluating them, and developing them to understand or solve science problems.	4.07	0.783	13
1-13	4.26	0.512	-

The mean rating for science teachers' perceptions of how to integrate STEM is 3.84. The mechanism that the most participants agreed on was holding activities that support learning mathematics, technology, and engineering and help students learn and apply science concepts; the mean rating for this mechanism is 4.24. The integrating mechanism that the science teachers agreed on the least was attempting to teach all four STEM concepts in one course in collaboration among the different teachers. The mean rating for this integration mechanism is 3.33 (see Table 2).

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Table 2
Means and Standard Deviations of Science Teachers' Perception of STEM Integrating Mechanism

Item	*M*	*SD*	Ranking
STEM integrating mechanism			
1. Activities that support learning mathematics, technology, and engineering and help students learn and apply scientific concepts.	4.24	0.693	1
6. Project-based learning that helps students employ concepts and practices in science, technology, engineering, and mathematics.	4.13	0.805	2
7. Create a unit related to contemporary issues or challenges that require students to employ previously studied STEM concepts and practices.	3.98	0.827	3
5. Combining two or three STEM fields to construct or apply integrated scientific knowledge.	3.87	0.839	4
3. Teaching science, technology, engineering, and mathematics in (separate) coordination between teachers' specializations to support students' knowledge and skills to solve specific science problems.	3.73	1.057	5
2. Utilizing technology or engineering to build concepts of science and mathematics.	3.63	1.132	6
4. Teaching science, technology, engineering, and mathematics in one course in cooperation between the teachers of these fields to support students' knowledge and practices to solve specific scientific problems.	3.33	1.233	7
1-7	3.84	0.608	-

The results also showed a strong agreement in the science teachers' perceptions of the importance of STEM, with a mean rating of 4.15. The teachers agreed that the most important aspect of STEM is "developing students' skills in solving science problems using creative methods." The two importance measures that the science teachers rated as the least important are "improving students' academic achievement" and "developing students' desire to engage in understanding and solving natural world problems related to science, technology, engineering, and mathematics" (Table 3).

Table 3
Means and Standard Deviations of Science Teachers' Perceptions of STEM Importance

Item	*M*	*SD*	Ranking
STEM importance			
6. Developing students' skills in solving science problems using creative methods	4.38	0. 700	1
1. Developing students' knowledge in science, technology, engineering, and mathematics.	4.37	0.625	2
4. Developing students' skills in critical thinking.	4.37	0.632	3
5. Developing students' skills in decision-making.	4.35	0.681	4
8. Enhancing students' awareness of the roles of science, technology, engineering, and mathematics together in addressing major challenges in society.	4.33	0.676	5
2. Developing students' science, technology, engineering, and math practices.	4.30	0.698	6
7. Improving students' academic achievement.	4.30	0.714	7
3. Developing students' desire to engage in understanding and solving natural world problems related to science, technology, engineering, and mathematics.	4.29	0.695	8
1-8	4.34	0.560	-
STEM meaning, integrating mechanisms, and importance	4.15	0.488	-

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For study question 2, regarding statistically significant differences in the upper-secondary school science teachers' perceptions of STEM education by science, Table 4 presents the univariate test findings. In particular, *F* for STEM meaning is 3.828, and $p = .023$. However, the univariate tests indicate that the teachers' perceptions of STEM's meaning and importance and of mechanisms for integrating the STEM concepts differed according to their specialization, with $F = 3.430$ and $p = .034$. Scheffe's test for post-hoc comparisons is used to distinguish the teachers' differing perceptions according to their specialties. Univariate testing reveals significant differences; the Scheffe's test results are presented in Table 5, which reflects particular differences between the physics and biology teachers' varying STEM perceptions.

Table 4
Univariate Test Results for Science Teachers' Perceptions of STEM Education by Specialization

First part	Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Meaning	Between groups	1.967	2	0.983	3.828	.023
	Within groups	64.73	252	0.257		
	Total	66.70	254			
Integrating mechanisms	Between groups	1.619	2	0.809	2.214	.111
	Within groups	92.12	252	0.366		
	Total	93.74	254			
Importance	Between groups	1.307	2	0.653	2.102	.124
	Within groups	78.33	252	0.311		
	Total	79.64	254			
Total	Between groups	1.605	2	0.803	3.430	.034
	Within groups	58.97	252	0.234		
	Total	60.58	254			

Table 5
Scheffe's Post-Hoc Comparisons

Variables	Specialization		Mean Difference	*p*
The concept	Physics	Chemistry	0.02683	.938
		Biology	0.20050	.039*
Science teachers' perceptions of STEM meaning, integrating mechanisms, and importance	Physics	Chemistry	0.03980	.857
		Biology	0.18803	.043*

Study question 3 asked whether there were statistically significant differences in upper-secondary school science teachers' perceptions of STEM education by years of experience. The findings in Table 6 show an *F* of .233, which was not statistically significant ($p = .792$), indicating that the teachers' perceptions of the meaning and importance of STEM as well as the mechanisms for integrating did not differ according to their years of experience.

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Table 6
Univariate Test Results for Science Teachers' Perceptions of STEM Education by Years of Experience

First part	Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Meaning	Between groups	0.146	2	0.073	.276	.759
	Within groups	66.556	252	0.264		
	Total	66.702	254			
Integrating mechanisms	Between groups	0.106	2	0.053	.142	.867
	Within groups	93.636	252	0.372		
	Total	93.742	254			
Importance	Between groups	0.122	2	0.061	.193	.824
	Within groups	79.52	252	0.316		
	Total	79.64	254			
Total	Between groups	0.112	2	0.056	.233	.792
	Within groups	60.46	252	0.240		
	Total	60.58	254			

Study question 4, the last question, was regarding statistically significant differences among upper-secondary school science teachers' perceptions of STEM education by academic degree. Table 7 indicates that *t* was 1.372, which was not statistically significant ($p = .171$). Thus, science teachers' STEM perceptions did not differ by their academic degrees.

Table 7
T-test Results for Science Teachers' Perceptions of STEM Education by Academic Degree

First part	Years of experience	*M*	*SD*	*t* test		
				t	*df*	*p*
The concept	Bachelor	4.26	0.510	1.722	253	.086
	Postgraduate	4.41	0.508			
Integrating mechanisms	Bachelor	3.83	0.609	0.620	253	.536
	Postgraduate	3.90	0.601			
The importance	Bachelor	4.31	0.562	1.344	253	.180
	Postgraduate	4.45	0.537			
Total	Bachelor	4.13	0.490	1.372	253	.171
	Postgraduate	4.25	0.471			

Discussion

Engineering is considered a foundation of STEM education. In this study, science teachers strongly agreed on the role of engineering in constructing and applying science concepts but ranked it last in importance in terms of the meaning of STEM. This could be attributed to the fact that science curricula are based on the

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National Scientific Education Standards, which place less emphasis on engineering practices than the NGSS. The teachers herein agreed on the role of mathematics in learning and applying science concepts. This result is consistent with findings by Al-Anzi and Al-Jabr (2017) and Ambosaidi et al. (2015) in that science teachers perceive considerable integration between science and mathematics.

In addition, the science teachers in this study agreed that "scientific activities that support learning mathematics, technology, and engineering and help students in learning and applying scientific concepts" were the most important mechanism for integrating the concepts of STEM in education. It was attributed to the aforementioned similarity between this mechanism and the structure of activities in science curricula. Some studies have indicated moderate levels in terms of the incorporation of mathematics into teaching from science books (Al-Hamidani, 2017; Al-Beez, 2017) but a minimal inclusion of technology and engineering (Al-Ahmad and Al-Buqami, 2017; Al-Beez, 2017; Al-Hamidani, 2017; Al-Ahmadi, 2016). The result herein agrees with the aforementioned findings and with those of Wang (2012), who found that science teachers recognized technology and math as tools that can help learners better understand science matters.

Furthermore, it was attributed to the high agreement among the science teachers in this study that "project-based learning helps students in employing concepts and practices in science, technology, engineering, and mathematics" to the existence of professional development programs for science teachers for project-based learning; it is, thus, not a new concept. This finding is consistent with those from Sandall (2016), Owens (2014), and Turner (2013) in that project-based learning has a fundamental role in integrating science, technology, engineering, and mathematics.

It was also considered that science teachers' moderate agreement on the importance of creating "a unit related to contemporary issues or challenges, which requires students to employ previous studied concepts and practices in science, technology, engineering and mathematics" was related to how science curricula often end with an investigative activity that aims to employ two or more STEM concepts and practices. Consistent with the findings herein, Al-Hamidani (2017) found statistically significant differences in incorporating STEM activities into physics teaching, in particular, for lab activities because these were designed in the form of projects. Additionally, it might be easier for teachers to guide students in applying previously taught concepts than to attempt to build new knowledge through course projects, a method Slough and Milam (2013) identified as common in school projects.

Moreover, the finding of science teachers' perceptions about the importance of STEM, for which there was a high agreement among them, is in agreement with previous studies. Park et al. (2016) found that teachers believed STEM teaching enhanced students' learning, creative thinking, and personality building, and the teachers in Turner's (2013) investigation believed that STEM teaching developed 21st-century skills. Wang (2012) also indicated that science teachers believed that STEM teaching gave learners the opportunity to apply their knowledge in life situations.

In addition, it was attributed to the fundamental differences between physics and biology teachers' perceptions of the meaning and importance of STEM and of integrating mechanisms to the fact that the nature of physics ties it more closely to concepts of geometry, algebra, and arithmetic than to biology. Abdel-Hamid et al. (2015) indicated that 46 engineering skills related to the following content should be incorporated into physics textbooks: vectors and analysis of forces and field, followed by algebraic skills (24 skills), arithmetic (11 skills), and statistical (5 skills).

In contrast, the absence of significant differences between science teachers' perceptions of STEM education by their years of experience or academic degrees can be attributed to the fact that the concept of STEM is based on philosophical and logical foundations that stem from the unity of scientific knowledge, which cannot be partially constructed or applied. Furthermore, "STEM" is a modern term, but its roots belong to the theory of constructivism, which existing science curricula are based on, and this makes it acceptable to science teachers irrespective of their education or years of experience. This finding is in agreement with Ambosaidi et al. (2015) and Smith et al. (2015) in that science and agriculture teachers did not differ in their perceptions of the concept of STEM according to their years of experience. However, the results of this study contradict Park et al.'s (2016) finding that teachers who had 15 or more years of experience were more accepting of the concept of STEM and its importance than teachers who had fewer than 5 years of experience. This difference may be attributable to the types of schools that were studied; specifically, Park et al. (2016) studied schools with a STEM focus.

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Conclusions and Implications

An interest in STEM education, as it supports the building and application of scientific knowledge to solve the problems of society and develop its economy, was an impetus to reveal the perceptions of science teachers of STEM. This study aimed to recognize science teachers' acceptance of STEM requirements and to guide professional development programs. However, due to the low response of the upper-secondary school science teachers to the research tool that came at a rate of 37.5% of the sample, the generalization of this study results became limit. Moreover, the sample of this study were female which limits the ability to generalize the results.

The results revealed a high level of agreement regarding the concept and importance of STEM. However, there were some difficulties related to the teachers' preparation. Thus, this study recommends intensifying professional development programs in terms of employing engineering. This will lead to learning science that goes beyond a general engineering framework and concepts. The programs should relate to the science content teachers are already teaching.

This study showed that in a rather high standard deviation values in some science teachers' perceptions of the integration mechanisms. Thus, an analytical study can be recommended to reveal mechanisms of integration in studies that have researched the effectiveness of STEM education on learning outcomes.

For future studies, researchers should explore the relationship between science teachers' perceptions of the concept of STEM and their teaching practices. Further, analytical studies should be conducted to identify mechanisms for integrating STEM concepts into science teaching using dependent variables such as learners' interest in STEM fields and learning.

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Declaration of Interest

Authors declare no competing interest.

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