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Secondary Stage Science Teachers' Perceptions toward STEM Education in Saudi Arabia

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Abstract: Many Saudi students lack the motivation to pursue STEM careers due to their teachers' limited experience and low efficacy in teaching science, technology, engineering, and mathematics (STEM). Teachers' perceptions are central to efficient STEM education; however, little is known about the perceptions of teachers toward STEM education in Saudi Arabia. Therefore, this study attempted to identify the perceptions of secondary stage science teachers toward STEM education and their knowledge about the requirements for its implementation. The study also investigated whether there were statistically significant differences that could be attributed to teachers' qualifications, years of experience, and specialization variables. A questionnaire was applied to 175 in-service science teachers. The results showed that the secondary stage science teachers had a medium level of positive perceptions toward STEM education and a high level of knowledge about the requirements for its implementation. It was also revealed that there were statistically significant differences in teachers' perceptions due to their qualifications and years of experience, in favor of teachers with graduate degrees and with more years of experience, while there were no statistically significant differences due to teachers' specialization. Based on the findings of this study, a number of recommendations on improving science teachers' knowledge of STEM education and the requirements for its implementation are provided.

Keywords: teacher perceptions; STEM education; science teachers; Saudi Arabia

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1. Introduction

Recent developments in technology and science have led to shifts in societal needs, resulting in the emergence of new professions and jobs. All countries of the world are trying to achieve economic development by providing qualified employees to work in the fields of science, technology, engineering, and mathematics (STEM). According to Langdon et al. [1], STEM jobs are essential for countries' economic growth and global competitiveness.

Educational systems focus on STEM education so that the future workforce will be trained well and face global economic competition [2,3], because STEM education in all stages ultimately increases the number of graduates who choose to work in the STEM fields [4]. According to the National Research Council [5], one of the main objectives of STEM education is to train a skilled workforce for careers in STEM industries. It is crucial to prepare upcoming generations to contribute to the modern economy by prioritizing the investment in STEM skills development. In this way, economic development can be achieved [6,7]. Providing students with positive experiences in STEM education may contribute to increasing their tendency toward STEM fields and boost their belief that they can be successful in these fields.

In Saudi Arabia, the Ministry of Education has been targeting the latest successful trends in the field of educational development. Since 2011, the ministry has been interested in STEM education as one of the most important policies aimed at improving student performance in the fields of science, technology, engineering, and mathematics [8].

As a result, understanding science teachers' perceptions toward STEM education and their knowledge of the requirements for its integration into their classrooms is critical to its successful implementation, as well as to the advancement of teachers' professional development in STEM education [9].

It is essential that administrators and policymakers identify the means of support that teachers believe would enhance their work as STEM professionals, as well as discovering teachers' understanding and viewpoints on STEM education and its requirements. After a review of the relevant literature, it can be noted that there is a scarcity of studies that investigate how science teachers perceive STEM education as well as what factors might predict teachers' perceptions toward STEM education and its integration into science teaching. The limited available evidence was mostly qualitative in nature [10,11]. This study serves as a novel attempt to identify Saudi science teachers' perceptions toward STEM education and what they believe is necessary for its integration into science teaching. The study's reliance on valid quantitative data is expected to yield reliable findings that would allow for the development of effective intervention strategies to assist and support Saudi science educators in the successful implementation of STEM education.

In its attempt to achieve its goals, this study sought the answers to the following questions:

- What are the perceptions of secondary stage science teachers toward STEM education and the level of their knowledge about the requirements for its implementation?
- Do secondary stage science teachers' perceptions about STEM education differ according to the qualification, years of experience, and specialization variables?

2. Background and Literature Review

STEM education has been implemented in the USA since the early 1990s to integrate various disciplines [12]. It is a pedagogical approach that focuses on integrating science, technology, engineering, and mathematics into education. It has been recognized as an effective approach to increasing students' motivation and interest in learning STEM disciplines [9]. Science, technology, engineering, and mathematics are considered an important part of education in the competitive global market. Therefore, STEM education is more than just an educational reform attempt. It is a comprehensive approach that emphasizes scientific multidisciplinarity to prepare a generation of students who possess knowledge and skills in all STEM fields, thus producing graduates capable of effectively joining the professions offered by this approach. The STEM disciplines can be outlined as follows [6,13,14]:

- Science, which includes knowledge; skills; methods of scientific and creative thinking; decision making; and scientific values and trends;
- Technology, which includes scientific, engineering, and computer science applications;
- Engineering design, which includes providing a basic foundation of technological culture at the high school level and preparing students to study engineering design after the high school stage;
- Mathematics, which includes teaching a broad base of mathematics basics and solving mathematical problems.

STEM education is not a mere replacement for science or mathematics teaching. It is an integrative approach that necessitates explicit connections between disciplinary content and practices [15]. In this approach, students can be observed working in the context of realistic situations on tasks that require them to use knowledge and skills from multiple disciplines.

The main goal of STEM education is to prepare scientifically knowledgeable individuals who are capable of employing their understanding of the natural world, scientific practices, and technology to make decisions, solve problems, and enhance their quality of life [16]. According to the National Research Council, the main goals of STEM education are increasing the number of students and workers pursuing advanced degrees in STEM fields; enhancing the participation of women and minorities; increasing the number of qualified STEM workers; and promoting STEM education for all individuals, including those who are not seeking STEM-related careers [5]. Thomasian [13] outlined two main goals for STEM education: increasing the number of high school graduates who are prepared for STEM careers to enhance workforce creativity, and improving the knowledge of science, technology, engineering, and mathematics for all individuals and equipping them with STEM concepts that will enable them to innovatively solve their daily-life problems. ALshehemeah [17] recommended using STEM education to positively impact creative thinking and academic achievement, while Hartzler [18] found that integrated curriculum programs were successful in teaching science and mathematics across all levels, particularly benefiting middle school students by improving achievement, motivation, and self-efficacy. Furthermore, studies by Zhumabay et al. [19], Ardianti et al. [20], and Sungur et al. [21] indicated that implementing STEM education enriched educational experiences for middle and high school students, enhancing their participation, critical thinking, and problem-solving skills.

A country that adopted STEM education in its educational system would be able to achieve the goals outlined above, thus enhancing its global economic competitiveness and assisting individuals in achieving economic security in their professional lives. Barakos et al. [16] indicated that STEM education focuses on broadening students' understanding of STEM disciplines by providing specialized training in related professions, which would lead to the development of the workforce in the STEM fields. The American government emphasized supporting STEM education in its 2012 budget by focusing on two main goals: preparing content-proficient teachers who use student-engaging methods across all STEM fields, as well as enhancing STEM education at university level and increasing graduates with credentials in these fields [22]. Furthermore, the Hanover Research stressed the importance of STEM education in preparing students to face the challenges and seize the opportunities of the 21st-century economy. STEM education improves the overall impact and effectiveness of the educational system at all levels, focuses on continuous professional development for teachers, and educates the workforce in STEM fields. These benefits increase productivity and innovation; achieve economic growth; and enhance job security [13,23].

There are several ways in which STEM education can be implemented. Aldosari [8] presented a number of methods for implementing STEM education in classrooms, such as teaching one STEM discipline as an independent subject separate from the others; teaching STEM disciplines collectively while focusing on one or two specific disciplines among the four; integrating one STEM discipline into other subjects; and finally, integrating all disciplines simultaneously into one integrated subject where the content of technology, engineering, and mathematics is studied within the science curriculum. This last method is the most used. The National Research Council pointed out that the success of STEM education depends on three criteria: student outcomes in STEM; the types of schools implementing STEM (selective, comprehensive, or vocational); and the STEM instruction and school practices that provoke students' interest and engage them in learning [5].

The implementation of STEM education should be reflected in a coherent and rigorous curriculum that emphasizes depth rather than breadth in STEM disciplines. Educational technologies should also focus on STEM education and include various activities such as project-based learning, hands-on laboratory learning, workplace experiences, and the use of advanced technological teaching tools as well as the traditional teacher-led instruction. To increase student interest in STEM education, various extracurricular activities should be offered such as summer programs and after-school enrichment activities, as well as science fairs and competitions. STEM education standards include the precise learning and application of science, technology, engineering, and mathematics contents; the integrative merging of these contents; the explanation and delivery of science, technology, engineering, and mathematics information; engaging in inquiry, research, logical thinking, and collaborative teamwork; and applying technology strategies [24,25].

A number of advantageous characteristics of STEM education can be outlined. STEM-based teaching prompts teachers to make students the center of the learning process in which students learn by conducting scientific research, making inquiries through projects, and solving real-life problems. STEM-based teaching emphasizes the integration of science branches while drawing on the strong connections and intersections between them. It also highlights the professional development of teachers through continuous training to keep up with rapid developments in the fields of science and technology. Additionally, it focuses on developing teachers' and students' 21st-century skills such as creative and critical thinking skills, conducting research, and team work. Furthermore, it recognizes the importance of linking families with schools and other community institutions [26–28].

Some studies have highlighted the significant role of teachers in STEM education. Reeve [29] emphasized the importance of teachers' willingness and motivation to learn more about the connections between STEM concepts and disciplines as well as having a good understanding of the standards included in each discipline. Frykholm and Glasson [30] aimed to uncover the impact of using an integrated model of mathematics and science and to identify teachers' perceptions toward it. The study found positive perceptions among teachers toward the integrated model of mathematics and science, despite the difficulty of integrating complex mathematical concepts.

On the other hand, there are challenges that face teachers when implementing STEM education. Some studies indicated that while teachers were capable of explaining the interdisciplinary nature of STEM [31–36], these teachers faced challenges in teaching STEM due to the lack of STEM training [37–39]. Time management and shortages in technical resources were other challenges that teachers had to face while implementing STEM education [28,32,40,41].

Previous studies have stressed the importance of teachers' understanding of the integration between the STEM disciplines. These studies argued that the effective implementation of STEM education in teaching is influenced by teachers' positive attitudes toward STEM education; their knowledge of its importance and role in achieving educational goals; the mechanisms for its implementation in the educational process; and their role as teachers and the role of students in this implementation. In addition, teachers' awareness of the requirements of STEM education and their possession of research, digital, and training skills are key factors that are as important as preparing school environments with the necessary tools and facilities for implementing STEM education activities [6,10,11,19,31,32,38,42–46]. Therefore, this study aimed to explore science teachers' perceptions toward STEM education and their knowledge of the requirements for its implementation.

Perceptions in education are opinions, mental structures, or ideas that individuals hold about a subject, event, procedure, or process. They either align with accurate scientific interpretations, making them valid scientific perceptions, or they diverge from accurate scientific interpretations, making them alternative perceptions which could be inaccurate, preconceived, partially formed, or incomplete ideas [35,47,48]. As a result, understanding teachers' personal perceptions about teaching a particular field of knowledge and their perceptions about performance effectiveness is considered a preliminary and fundamental step in planning and developing programs in this field.

Furthermore, perceptions play a crucial role in forming and guiding teachers' behaviors and practices, and they shape the nature of the interaction between them and their students inside the classroom. This relational connection between a teacher's perception and their teaching performance level also correlates with students' overall achievement levels. Since teachers' perceptions toward STEM education strongly influence their willingness to adopt this approach and the teaching strategies associated with it, studying their perceptions and beliefs provides curriculum planners, designers, and developers with insights into what should be emphasized in STEM education professional development programs, as well as into evaluating existing STEM education programs [43,48–51].

Governments go to great lengths to ensure the implementation of STEM programs and activities, but teachers, particularly science teachers, are the single most important factor in the equation [52]. These teachers are expected to provide lessons that stimulate students' critical and innovative thinking, and help them understand scientific content and concepts [53]. Science teachers should use strategies that provoke students to think using higher cognitive processes so that they achieve profound understanding of scientific concepts [42].

Consequently, teachers' perceptions play a crucial role in the effective implementation of STEM; however, there is still a lack of clarity regarding the influences on teachers' perceptions toward STEM education [6,45]. The way educators perceive STEM education can be influenced by various factors such as education, profession, training, personal traits, and relationships with others [54]. These perceptions also impact the way science teachers structure their lessons and the way they deliver them. A lively instructor with a favorable outlook on STEM appears to be the primary factor in ensuring the successful implementation of STEM programs [52].

Since they are an integral part in the implementation of STEM education, science teachers need to recognize the importance of STEM education and the positive effects of its integration into science teaching [55,56]. In other words, they should realize that STEM education leads to higher student expectations after high school, increases science literacy, and challenges students to think critically about current issues and future implications in their own lives [57,58]. Science teachers' conviction of the benefits of STEM education to students is essential to motivate them to integrate it into their classrooms [59].

In Saudi Arabia, a framework for the professional development of science teachers has been proposed in light of STEM education principles and requirements. This framework emphasizes professional development in knowledge content by identifying the required training and development needs; enhancing the content of STEM fields; and adopting professional development strategies for STEM fields [60]. In this study, science teachers of the secondary stage in Saudi Arabia were selected because this stage marks the final phase of general education, after which students transition to higher education. It is essential for students graduating from this stage to possess the knowledge and skills associated with science, technology, engineering, and mathematics (STEM). Because at the secondary stage in Saudi Arabia science is taught as separate subjects, i.e., physics, chemistry, and biology, the Saudi Ministry of Education has emphasized the integration of technology, engineering, and mathematics into these subjects by the teachers. It is crucial, therefore, for these teachers to hold positive beliefs and perceptions toward STEM-integrated curricula and to understand the requirements for STEM implementation to be able to integrate it into their classrooms.

3. Methodology

3.1. Research Method and Design

This study used a descriptive approach to investigate the science teachers' perceptions toward STEM education in Saudi Arabia and their knowledge of the requirements for its implementation. To achieve this objective and answer the study questions, quantitative data were collected via a questionnaire.

3.2. Participants

The study took place in Taif city, which is part of the Mecca region of Saudi Arabia. The study included 175 secondary stage science teachers in Taif city who were chosen randomly for the first semester of the 2023–2024 academic year. The teachers worked at 27 schools that were selected randomly. An electronic questionnaire was sent to the participants via official emails and WhatsApp.

The participants were informed about the importance of confidentiality and independence when data collection began. Every participant agreed to take part in the study. A consent form was used to officially document their agreement, and they also received a participant information sheet. The questionnaire was completed by 175 secondary stage science teachers who taught biology, chemistry, and physics.

3.3. Study Instrument (Closed-Ended Questionnaire)

The study utilized a closed-ended questionnaire. After defining the study's objectives, i.e., exploring secondary stage science teachers' views on STEM education and examining how these views correlate with their academic background, teaching experience, and area of expertise, the questionnaire and its items were developed based on the literature reviewed above [9,50,60].

The questionnaire consisted of two sections. The first section contained questions about the participants' characteristics (qualifications, years of experience, and specializations). The second section contained 34 questions covering two domains: perceptions toward STEM education and knowledge of the requirements for its implementation. It was conducted using a 5-point Likert scale, (very high, high, medium, weak, and very weak). To test the questionnaire's validity and reliability, it was applied to a pilot sample of 44 science teachers. To confirm the questionnaire's validity, the internal consistency was assessed by calculating the correlation between each item's score and the total score of its respective domains, ranging from 0.47 to 0.81. Following that, the correlation coefficient was calculated between the overall score of each section and the overall score of the complete questionnaire, ranging from 0.51 to 0.90. The questionnaire's reliability was verified using the Cronbach's alpha, which yielded a coefficient of 0.82, exceeding 0.7 and indicating the high reliability of the questionnaire. Confirmatory factor analysis (CFA) was conducted to verify the structural validity of the questionnaire. Principal component analysis (PCA) was employed for teachers' responses to the questionnaire items, and the axes were rotated using the Varimax method. It was found that there were two factors, with items distributed across these factors. Factor loadings ranged from 0.33 to 0.72 for the first factor and from 0.37 to 0.79 for the second factor. These values confirmed the factorial validity of the questionnaire.

By calculating the range between the highest score (5) and the lowest score (1) ($5 - 1 = 4$) and dividing it by the number of the scale categories (5), we obtained the category length ($4 \div 5 = 0.80$). Then, this value was added to the lowest value in the scale, and the process was repeated to yield the criteria for judging the questionnaire responses as the following: if the mean is 1.80 or less, the degree of presence is "very weak"; more than 1.80–2.60 is "weak"; more than 2.60–3.40 is "medium"; more than 3.40–4.20 is "high"; and more than 4.20 is "very high".

To answer the study's questions, SPSS software (27) was used to calculate the means of the participants' responses to the two domains of the questionnaire. The *t*-test was also employed to determine the differences attributed to the qualification variable, whereas the one-way ANOVA was used to identify the differences attributed to the years of experience and specialization variables.

4. Study Results

4.1. The Results of the First Question

The study's first question was "What are the perceptions of secondary stage science teachers toward STEM education and the level of their knowledge about the requirements for its implementation?" In order to answer this question, a quantitative analysis was conducted to interpret the results obtained through the questionnaire. The results were presented as the following:

4.1.1. The First Domain: Perceptions toward STEM Education

The means and standard deviations for the responses to the items of the first domain were calculated as shown in Table 1.

Table 1 indicates that the means related to the first domain ranged between 2.24 and 2.99, reflecting weak to medium degrees. The overall mean of the domain was 2.67 with a standard deviation of 0.28, which indicates a medium level of positive perceptions among teachers. Item 12, "STEM education links scientific concepts with life skills" ranked first with a mean of 2.99 and a standard deviation of 0.97 while item 2 "STEM education supports the foundations of a knowledge-based economy" ranked last with a mean of 2.24 and a standard deviation of 0.64.

Table 1. Means and Standard Deviations of Participants' Responses Regarding the First Domain of the Questionnaire (Perceptions toward STEM).

No.	Item	Mean	SD	Rank	Level of Approval
1	Applying principles of engineering design and technology promotes learning through problem solving and investigation.	2.29	0.79	15	Weak
2	STEM education supports the foundations of a knowledge-based economy.	2.24	0.64	16	Weak
3	STEM education helps students to develop their thinking.	2.33	0.69	15	Weak
4	STEM education meets workforce needs in professional science disciplines.	2.38	0.76	13	Weak
5	STEM education makes science classes full of useful activities for students.	2.55	0.81	12	Weak
6	STEM education uses technology and engineering design to bring students real-world practice.	2.65	0.83	11	Medium
7	STEM education enables students to apply appropriate concepts and practices.	2.69	0.81	8	Medium
8	STEM education contributes to comprehensive thinking about a particular problem or situation.	2.74	0.77	6	Medium
9	STEM education links scientific knowledge to future careers.	2.73	0.77	7	Medium
10	STEM education gives students the engineering skills to live in a better, globally competitive society.	2.89	0.91	5	Medium
11	STEM education gives students the skills needed for the 21st century.	2.98	0.92	2	Medium
12	STEM education links scientific concepts with life skills.	2.99	0.97	1	Medium
13	STEM education develops students' interests toward scientific and professional disciplines.	2.92	0.94	4	Medium
14	STEM education enables students to build knowledge and put it to practical use.	2.68	0.87	9	Medium
15	STEM education enables students to understand the world and its problems in an integrated, not fragmented way.	2.66	0.89	10	Medium
16	STEM education links scientific concepts and mathematical, technical, and engineering knowledge in an integrated format.	2.93	0.87	3	Medium
Total		2.67	0.28		Medium

4.1.2. The Second Domain: Requirements for Teaching Using STEM Education

The means and standard deviations for the responses to the items of the second domain were calculated as shown in Table 2.

Table 2. Means and Standard Deviations of Participants' Responses to the Second Domain of the Questionnaire (Requirements for Implementing STEM Education).

No.	Item	Mean	SD	Rank	Level of Approval
1	Using educational activities that enable students to develop their logical scientific thinking and computational thinking	3.78	0.89	13	High
2	Providing appropriate places inside and outside the school through which integration of science, technology, engineering, and mathematics can be implemented	3.97	0.80	6	High
3	Training science teachers on ways to direct their students toward scientific research, designing experiments, and processing data	3.85	0.84	10	High
4	Providing science teachers and students with the opportunity to discover, design, and implement solutions	3.83	0.87	12	High
5	Enriching science curricula with topics that raise questions about natural phenomena and scientific discoveries	3.89	0.86	9	High
6	Linking technology to scientific topics and using it practically	4.14	0.85	2	High
7	Using the method of exploration, investigation, and problem-solving in the educational-learning process in general and science education in particular	3.93	0.92	8	High
8	Providing students with social and group skills such as cooperation and exchanging meaningful dialogs between them	3.84	0.86	11	High
9	Using science, technology, and mathematics principles in the engineering design process	3.74	0.81	15	High
10	Providing science teachers with the opportunity to be creative and develop their expertise in the field of teaching	3.65	0.79	16	High
11	Applying engineering design principles and technology to science teaching strategies	3.42	0.64	17	High
12	Subjecting science teachers and students to training programs related to engineering design	4.10	0.87	4	High
13	Giving science teachers flexibility in implementing the semester plan since the activities require time	4.07	0.91	5	High
14	Supporting school administration and educating it on the integration approach between science, engineering, technology, and mathematics	4.16	0.87	1	High
15	Interest in engineering as a way of thinking and solving problems	3.22	0.56	18	Medium
16	Developing specialized educational materials in the field of integration between science, technology, engineering, and mathematics such as digital simulation programs and video programs	4.13	0.82	3	High
17	Providing science teachers with scientific literature and research related to the integration approach	3.96	0.91	7	High
18	Building partnerships between the Ministry of Education and local community institutions to support the learning process in science, mathematics, technology, and engineering	3.75	0.94	14	High
Total		3.86	0.19		High

Table 2 shows that the means related to the second domain ranged between 3.22 and 4.16, projecting medium to high degrees. The overall mean of the domain was 3.86 with a standard deviation of 0.19, which indicates a high level of knowledge among teachers about the requirements for teaching using STEM education. Item 14, "Supporting school administration and educating it on the integration approach between science, engineering, technology, and mathematics", ranked first with a mean of 4.16 and a standard deviation of 0.87 while item 15, "Using educational activities that enable students to develop their logical scientific thinking and computational thinking", received the lowest score and ranked last with a mean of 3.22 and a standard deviation of 0.56.

4.2. The Results of the Second Question

The study's second question was, "Do secondary stage science teachers' perceptions about STEM education differ depending on the qualification, years of experience, and specialization variables?"

4.2.1. Qualifications

The results of the questionnaire were divided into two groups based on the qualifications of the participants: one group for teachers with a bachelor's degree and another for teachers with a graduate degree. Then a *t*-test was conducted to examine the significance of the differences between the means. The results were as shown in Table 3.

Table 3. Means and Standard Deviations for the Two Domains of the Questionnaire According to the Qualification Variable and the Results of the *t*-test.

Domain	Qualification	N	Mean	SD	t	df	Sig.
Perceptions toward STEM education	Bachelor's	108	2.62	0.31	2.84	173	0.005
	Postgraduate Studies	67	2.74	0.21			
Requirements for implementing STEM education	Bachelor's	108	3.81	0.17	4.85	173	0.000
	Postgraduate Studies	67	3.94	0.19			

Table 3 shows that there were statistically significant differences between the means of the responses of the teachers with a bachelor's degree and those of the teachers with a graduate degree in the two domains of the questionnaire. The difference for the first domain was 0.12 and for the second domain it was 0.13; these differences were in favor of teachers with a graduate degree.

4.2.2. Years of Experiences

Table 4 shows the results of using the ANOVA test to analyze the significance of the differences between the means of the teachers' responses based on the years of experience variable (less than 5, 5–10, and more than 10 years).

Table 4. The ANOVA Test Results for Analyzing the Means of the Teachers' Responses based on the Years of Experience Variable.

Domain	Variance Source	Sum of Squares	df	Mean Square	f	Sig.
Perceptions toward STEM education	Between Groups	0.54	2	0.28	3.51	0.032
	Within Groups	13.15	172	0.08		
	Total	13.69	174			
Requirements for implementing STEM education	Between Groups	0.22	2	0.11	3.24	0.042
	Within Groups	5.92	172	0.034		
	Total	6.14	174			

Table 4 shows that there were statistically significant differences between the means of the teachers’ responses in the two domains of the questionnaire based on the years of experience variable. To determine the direction of these differences, post-hoc comparisons were used, and the results are presented in Table 5.

Table 5. Post-hoc Comparisons of the Means of the Teachers’ Responses in the Two Domains of the Questionnaire Based on the Years of Experience Variable.

Domain	Years of Experience	From 5 to 10 Years	More Than 10 Years
Perceptions toward STEM education	less than 5 years	0.14 *	0.12 *
	from 5 to 10 years	-	0.02
Requirements for implementing STEM education	less than 5 years	0.08 *	0.09 *
	from 5 to 10 years		0.02

* The mean difference is significant at the 0.05 level.

Table 5 indicates that there were statistically significant differences between the means of the teachers’ responses in the two domains of the questionnaire, depending on the years of experience variable. The differences were between teachers with less than 5 years of experience and those with from 5 to 10 years of experience, in favor of the teachers with more years of experience. Similarly, there were significant differences between teachers with less than 5 years of experience and those with more than 10 years, favoring the latter. However, the differences were not significant between teachers with from 5 to 10 years of experience and those with more than 10 years.

4.2.3. Specialization

Table 6 shows the results of using the ANOVA test to analyze the significance of the differences between the means of the teachers’ responses based on the specialization (physics, chemistry, or biology) variable.

Table 6. The ANOVA Test Results for Analyzing the Means of the Teachers’ Responses Based on the Specialization Variable.

Domain	Variance Source	Sum of Squares	df	Mean Square	f	Sig.
Perceptions toward STEM education	Between Groups	0.194	2	0.097	1.23	0.294
	Within Groups	13.494	172	0.056		
	Total	13.688	174			
Requirements for implementing STEM education	Between Groups	0.089	2	0.045	1.27	0.284
	Within Groups	6.055	172	0.035		
	Total	6.145	174			

Table 6 shows that there were no statistically significant differences between the means of the teachers’ responses according to the specialization variable in the two domains of the questionnaire.

5. Discussion

In Saudi Arabia, there is a focus on enhancing and developing human resources capacity, particularly in the STEM fields, to achieve the goal of transitioning to a higher economic level in accordance with the objectives of the Kingdom’s Vision 2023 [61]. However, Saudi Arabia has been lagging compared to developed countries in terms of the quality of STEM education. This inadequacy is reflected in the poor performance of university graduates in STEM fields and the lack of preparedness for such fields.

This study is thought to be significant for a number of reasons. First, it adds to our knowledge of how science teachers in Saudi Arabia see STEM education and what they believe is needed for implementing it within the Saudi context. It highlights the importance of science teachers' perceptions toward STEM education as a key element in its successful and effective implementation.

Second, this study contributes to improving science teachers' practices and abilities. The study offers recommendations that would help officials and decision makers in the Saudi Ministry of Education to design relevant STEM professional development programs for science teachers. When science teachers' perceptions toward STEM education are known and understood, effective programs can be created to help them develop their teaching performance. This should guarantee that STEM professional development programs become more efficient and meet teachers' needs, which would ultimately enhance students' abilities, improve their achievements, and raise their interests in careers in all areas of STEM.

Third, this study may contribute to reforming STEM education. While Saudi Arabia is making efforts and providing funds to improve STEM education, exploring and understanding teachers' perceptions and attitudes toward STEM education could help allocate education resources well. Therefore, the results of this study would be necessary for the improvement and development of STEM education in Saudi Arabia.

The results point out that the science teachers possessed a medium level of positive perceptions toward STEM education. This result may be attributed to the novelty of the concept of STEM education among science teachers in Saudi Arabia and the lack of training courses for teachers on how to integrate it into the educational process. This can also be attributed to other factors such as the shortcomings of some components in the training programs for pre- and in-service teachers; teaching and administrative overload; insufficient class time (actual teaching time); and the inadequacies of lab equipment in many schools. It is necessary, therefore, for secondary stage science teachers to be provided with pre- and in-service training programs that target the development of their knowledge in modern trends in science education, particularly STEM education. Doing so would enable teachers to engage their students in this knowledge, thus developing them in the areas of STEM education.

The results of this study were consistent with some studies which pointed out that heavy teaching loads, lack of resources, support, and training in STEM [35] made teachers feel insecure about being able to fully and successfully implement STEM education. These concerns that they were not prepared to use STEM education with their students affected their teaching practices [24,25,51]. Additionally, the results of this study aligned with the findings from other studies that indicated inadequate implementation of STEM education by science teachers [11,62,63].

The study results showed that teachers who had limited perceptions and knowledge about STEM education may feel that they are unable to effectively contribute to classroom learning during STEM activities. Teachers' perceptions toward STEM education influence their ability to learn and develop as STEM educators [64], and this would affect how they teach STEM-integrated curricula.

Some studies indicated that teachers were able to understand and explain the interdisciplinary concepts of STEM [31–34,36]. However, they faced challenges while teaching STEM due to the lack of training on how to implement it [37–39,51]. Additionally, there were studies that pointed out that teachers struggled with STEM implementation due to time constraints and the lack of resources [32,40,41].

Moreover, some studies suggested, with compelling evidence, that the workshops and training courses offered to teachers were beneficial for increasing their knowledge of modern trends in educational practices, particularly in the field of STEM education [28]. Furthermore, certain reports on STEM education indicated that some teachers believed that STEM education should be integrated into the curricula and syllabi offered in teacher preparation programs at the colleges of education at universities, and that science and mathematics teachers should receive in-service training [31].

The study results were consistent with those of [6,9,53,65], which suggested that within the context of STEM education, science teachers were forced out of their comfort zone.

The results differed from other studies [44,50,66] which indicated the presence of a high level of positive perceptions among teachers toward STEM education. The results also differed from those of Smith et al. [56], who showed that teachers possessed a high level of confidence in implementing STEM education.

The results also showed a difference in the perceptions toward STEM and the knowledge of its implementation requirements between teachers with a bachelor's degree and those with graduate degrees. This result was different from that of Al Omari [67], which found no significant differences in the perceptions of elementary stage teachers toward STEM education that could be ascribed to the qualification variable.

This result may be attributed to the fact that graduate programs address science curricula, their organization mechanism, and the integration of various academic subjects into science. These programs are also concerned with modern trends in teaching science such as STEM education. They include study materials that contain concepts and information related to STEM education, which makes teachers more knowledgeable about STEM education's importance, its methods of application, and the requirements for its implementation in science teaching.

The results showed that teachers with more years of experience had higher positive perceptions toward STEM education and more knowledge of its requirements. This result could be explained by the fact that the more experience a teacher has, the better acquainted they become with the reality of teaching science inside the classroom. Such a teacher would have an increased ability to understand the strategies for teaching science in general. Such an understanding would enable the experienced teacher to better grasp the aspects of integration between various academic subjects and science. This would ultimately reflect on the teacher's ability to integrate STEM education into their teaching, thus achieving the desired goals from a STEM-education standpoint. Solid experience in teaching science courses makes teachers more mindful of STEM education [59,68]. The results of this study were consistent with other studies suggesting that teachers' perceptions can be influenced by years of experience [6,44,60,69]. However, the results differed from those of Ambosaidi et al. [50], which showed that science teachers' perceptions of STEM education did not vary according to teaching experience.

When it comes to teachers' specialization, the results showed similarity in the perceptions of teachers of different specializations (physics, chemistry, and biology) toward STEM education and its requirements. This result may be ascribed to the similarity of the circumstances to which teachers of different specializations were exposed as they worked in similar schools and had been trained similarly during their university studies. In addition, the training courses and programs for in-service physics, chemistry, and biology teachers were, to a great extent, the same. Furthermore, the science curricula for physics, chemistry, and biology did not have specific and clear objectives that emphasized the importance of STEM education.

The results were in accordance with the findings of Al Omari [67], which showed no differences in the perceptions of elementary school teachers regarding STEM attributed to the variable of teachers' specialization. It also aligned with the results of Cinar et al. [48], which indicated no significant differences between the opinions of science and mathematics teachers regarding STEM education.

However, this result differed from the results of Al-Otaibi [44], which pointed out that there were differences in science teachers' perceptions toward STEM education according to the specialization variable. The result also differed from that of Alamodi [10], which revealed differences in the perceptions of female teacher candidates enrolled in an educational preparation program based on their specialization (physics, chemistry, or biology). Furthermore, the result was inconsistent with the findings of Wang [43], which demonstrated differences in teachers' perceptions toward implementing STEM education based on their specialization, leading to variations in their teaching practices when applying STEM education in the classroom.

6. Study Limits and Limitations

This study was confined to identifying the perceptions of secondary stage science teachers toward STEM education based on the study's instrument (the questionnaire). The study was restricted to a group of secondary stage science teachers in Taif city during the first semester of the 2023/2024 academic year. The study depended on the views of the participants; therefore, its results reflected an unescapable level of subjectivity. Moreover, the fact that the study was carried out in just one city, Taif, might raise questions about the applicability of the findings to teachers in different cities. Nevertheless, this study was carried out in public secondary schools similar to numerous others in Saudi Arabia, and it considered the perspectives of as many science teachers as possible.

7. Conclusions

In this study, the main result was that secondary stage science teachers possessed a medium level of positive perceptions toward STEM education in the Saudi Arabia context, and they had a high level of knowledge about the requirements for its implementation. There were differences in the teachers' perceptions according to their years of experience and specialization. Teachers with more years of experience and those with graduate degrees had a higher level of positive perceptions about STEM education and knowledge of its requirements.

This study is thought to be a pioneering study in STEM education in Saudi Arabia. It offers important insights into the potential and challenges of implementing STEM education in the Saudi context. Although it was limited to the teachers situated in Taif city in Saudi Arabia, its results could be generalized to other cities and even other nations with similar educational contexts.

A number of recommendations can be presented based on the findings of this study. Similar studies can be applied with teachers of the intermediate and elementary stages. Experimental studies could be conducted on training programs that prepare teachers in STEM education, in order to understand how to support science teachers as they attempt to integrate STEM education into their teaching.

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Data Availability Statement: The data that support the findings of this study are available on request.

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