Exploring Early Childhood Teachers' Beliefs About STEAM Education in Saudi Arabia

Ahlam A. Alghamdi¹

Accepted: 17 December 2021 / Published online: 12 January 2022
© The Author(s) 2022

Abstract

This study explores Saudi teachers' beliefs about STEAM education in early childhood education settings. The study sample consisted of 245 teachers working in kindergartens. The participants completed a survey comprising twelve items to elaborate teachers' beliefs toward implementing STEAM practices in their classrooms, as well as four close-ended questions to evaluate teachers' knowledge of and familiarity with the terminology of STEAM education and their professional training in STEAM-related content. The findings reveal overall positive beliefs toward STEAM education for young children and rather moderate beliefs regarding the implementation of STEAM practices. The results also reveal that teachers were somewhat familiar with the term STEAM; however, they reported limited knowledge of the integration process and basic strategies and skills needed for its implementation. The results also demonstrate that the majority of the Saudi teachers participating in this study believed they needed additional professional development and training regarding STEAM implementation. A chi-square test indicated statistically significant associations between teachers' knowledge of STEAM education and their beliefs and between teachers' previous professional training in STEAM education and their beliefs. The implications and future recommendations are also discussed.

Keywords STEAM education · Teachers' beliefs · Early childhood · Saudi Arabia

Introduction

STEAM education is commonly understood to be a multi-disciplinary learning approach for educating K-12 students that is based on a scientific approach. The term STEAM is an acronym for science, technology, engineering, arts, and math. STEAM refers to an educational philosophy that is designed to integrate these five key disciplines to support children's natural curiosity and foster their internal excitement for exploration and discovery. At the same time, children taught via STEAM must demonstrate critical thinking and creative problem solving to build a foundation for later academic achievement (Flinn & Mulligan, 2019). Educating young children for life and their future entails a new method that integrates multiple content areas to cause children to think critically in different ways. Children in the twenty-first century need additional critical-thinking skills to equip them

for future challenges (Dell'Erba, 2019; Mitchell & Forestieri, 2018). Education continues to experience increasing pressure to prepare students to cope with recent international problems, especially amid growing global competitiveness (Chao, 2016; Ramírez-Montoya, 2017).

STEAM originated in the United States as a response to concerns over a noticeable shortage of well-prepared students moving into STEM-related professions (National Research Council (NRC), 2012). The term STEM (without the A) was created in the early 1990s to represent four related academic disciplines (science, technology, engineering, and math). Initially, the acronym was SMET with science and math as the two major disciplines followed by engineering and technology; an initiative created by the National Science Foundation (Martín-Páez et al., 2019). However, the proposed acronym was difficult to rally around and there were concerns of SMET's potentially negative association with the word *smut* (Bybee, 2013; Catterall, 2017). Therefore, by 2001, the term STEM was widely used as a new perspective for teaching students to be creative problem-solvers in the new millennium (Bybee, 2013).

✉ Ahlam A. Alghamdi
Abghamdi@tu.edu.sa; Ahgam@yahoo.com

¹ Early Childhood Education Department, Taif University,
Taif 26571, Saudi Arabia

To incorporate creativity and artistic self-expression, STEM has since shifted to STEAM, with the *A* representing the arts. The integration of the arts into STEM learning has added spirits of creation and innovation, which can in turn develop imaginations through divergent pathways, in contrast to STEM's specifically scientific content. Integrating creative subjects such as art with more traditional subjects such as math and science bridges the learning experiences of both creative and logical-mathematical thinkers (Maslyk, 2016). Sousa and Pilecki (2013) have identified several reasons for integrating the arts into STEM. The arts engage the brain, develop cognitive growth, improve long-term memory, promote creativity, advance social growth, introduce novelty, and reduce stress. For young children, art is a natural way to tap into creative production and innovative building skills through playful, hands-on activities (DeJarnette, 2018).

Teachers' Beliefs and Practices Related to STEAM Education

Teachers' beliefs about teaching and learning approaches have been studied from various perspectives (e.g., Pajares, 1992; Rath, 2001; Valcke et al., 2010; Vartuli, 2005). Fives and Buehl (2004) suggested that teachers' epistemological beliefs and content knowledge can determine their pedagogical practices and whether they teach effectively and successfully. Teachers' pedagogical beliefs and attitudes about what they can accomplish through their pedagogy influence their teaching actions and behaviors. Teachers with positive attitudes toward innovative teaching—as in STEM education—tend to be more willing to conduct innovative teaching practices. What teachers believe about STEAM education shapes their pedagogical and instructional practices (Chen et al., 2021). A growing body of research has indicated that different factors—such as teachers' knowledge, professional development, preparation, and self-efficacy regarding STEM—impact teachers' STEM beliefs and implementation practices (Burrows & Slater, 2015; DeCoito & Myszkal, 2018; Jamil et al., 2018; Park et al., 2017). Research has also shown that the value teachers place on STEM education influences their willingness to engage and implement a STEM-based approach (Margot & Kettler, 2019).

The STEAM-focused teaching style is built upon knowledge and understanding of how to effectively deliver related instructions to students. In an unstructured way, students are exposed to STEAM concepts in a developmentally friendly and playful environment on a daily basis. A play-based, multisensory experience is a way of teaching young children how to ask questions and think of, search for, and invent their own solutions to relevant real-world problems (Horace, 2021; Saldaña, 2018). Preschool students are encouraged and supported to discover mindsets and logical thinking

within the intersection of science, technology, engineering, art, and math. As teachers in preschool design STEAM practices, they use play as a common ground for transdisciplinarity to integrate content and context (Wahyuningsih et al., 2020). Content integration is a method of blending multiple content areas into a single curriculum to help learners view the connections and relations between different subjects. Through context integration, a teacher focuses on a single component from one discipline and uses contexts from other disciplines to make the content more relevant to learners (Moore et al., 2020; Quigley et al., 2017; Wang et al., 2011).

The increased global attention given to STEAM has created a need to support effective teaching pedagogy and implementation practices in early classroom settings. STEAM-related professional skills have also created new competencies for teaching STEM education (Maiorca & Roberts, 2018). The STEAM educational paradigm has encouraged experts and professionals in the field of teacher education to address scientific thinking, integration skills, and workforce readiness among teachers and to highlight standards for guidance. For instance, the National Association of the Education of Young Children (NAEYC) has composed multiple position statements that support educators who teach STEM-related subjects by emphasizing these subjects' developmental appropriateness for young children; for example, the guidelines elaborated in National Association for the Education of Young Children (NAEYC) and National Council of Teachers of Mathematics (NCTM) (2002), National Science Teachers Association (NSTA) (2014), and National Association for the Education of Young Children & The Fred Rogers Center (2012).

A hallmark in the development of STEAM was the release of the Next Generation Science Standards (NGSS) in 2013. The NGSS are built upon collaborative, state-led efforts to develop standards that are coherent and rich in content and practice across the multiple disciplines and grades involved in science education. Each standard is presented in a framework for K-12 science education, with meaningful connections to math, technology, engineering, environment, society, and literacy. The NGSS have provided teachers with a wide range of practices and performance expectations to consider in their organizational structures that allow students to understand the world through coherent scientific connections (NGSS Lead States, 2013). Younger learners are expected to demonstrate grade-appropriate proficiencies for increasing performance mastery levels, which are learnable for children but broad enough to sustain continued investigations throughout their education (NGSS Lead States, 2013, p. 16).

STEAM in Saudi Early Childhood Education

Amid its increasing strides towards globalization, Saudi Arabia has faced real challenges in its efforts to reform its educational system to be on par with those of other nations. Over the last two decades, Saudi Arabia made significant attempts to reform its education system by giving more attention to STEAM content without explicitly mentioning the acronym. King Abdullah bin Abdul-Aziz's Public Education Development Project (KAAPEDP) was initiated in 2007 as an urgent call for reforming public education at all levels to keep pace with the country's widespread economic and social developments (Alnahdi, 2014). The project was known as the *Tatweer* program—an Arabic form of development—and was intended to reform the traditional Saudi school model into one with an innovative environment and advanced technology. In this project, heavy emphasis was placed on the importance of technology through investments in technology-oriented learning environments and heightened standards for teachers' qualifications (Alyami, 2014). However, the project said nothing specific regarding actual STEAM curricula.

In tandem with the reforms to Saudi education, including the *Tatweer* program, and with the cooperation of the NAEYC, the Ministry of Education (MOE) (2015) issued its Saudi Early Learning Standards (SELS) position statement in 2015. The position statement applied to preschool-aged children of 3 to 6 years and was intended to inform educators, teachers, parents, and care providers with the best practices, based on the basic characteristics of a child's age and developmental stage. The statement addressed seven standards regarding children's learning across all areas of development. One of the standards is *Cognition and General Knowledge*, which clearly expresses four related STEAM subjects, organized into four major strands: Mathematics, Science, Creative Arts, and Technology. Although engineering is not explicitly mentioned, the instructions detailed in this standard demonstrate inquiry-based integrations with engineering-specific content. For instance, concepts such as measurement, geometry, spatial sense, and shape dimension are all presented as scientific, logical thinking skills that involve both math and engineering. Each strand of the *Cognition and General Knowledge* standard is subdivided into the following multiple themes, which are clearly related to STEAM content:

- The *Science* strand addresses the inquiry skills children need to understand their natural world: *Scientific Inquiry*, *Physical Science*, *Life Science*, and *Environmental Science*. The relevant instructions proposed by this strand to support developmentally appropriate practices for children would be, for example, “name and identify different earth materials such as rocks, water, and dirt” or “sort

and categorize plants and animals by their physical characteristics.”

- The *Mathematics* strand is concerned with the study of operations that evoke logical-mathematical thinking through major mathematical concepts: *Patterns*, *Functions*, *Algebra*, *Data Analysis and Probability*, *Numerals*, *Quantity*, *Measurements*, and *Geometry*. A few examples for teachers to practice with students include “explore the concept of volume, by estimating size; recognize that numbers represent quantity to describe and create simple patterns” and “demonstrate an understanding of simple graphs by comparing two pieces of information.”
- The *Creative Arts* strand nurtures children's heads, hearts, and hands by fostering holistic interactions between children's minds, bodies, and actions. Children express their knowledge, thoughts, and emotions through avenues of *Artistic Expression*, *Dramatic Play*, *Chants*, and *Expressive Movement*. A few examples of practices recommended for teachers to perform with children include “recreate familiar environments, such as the household and classroom” and “use artwork as a way to express thoughts, feelings, and knowledge.”
- The *Technology* strand addresses students' basic familiarity with technology and the essential skills and knowledge needed for them to engage effectively with interactive technology and multimedia. Some activities considered to be appropriate to practice with children include “make a mechanical toy work by intentionally pushing buttons, turning knobs, and pulling pull-strings, as appropriate” and “play with mechanical toys and learning games, with some assistance” (Saudi Early Learning Standards (SELS), 2015).

In addition, the *Cognition and General Knowledge* standard in the SELS statement provides teachers with a range of age-appropriate practices that demonstrate proficiencies and indicate performance expectations for young learners. The practices also encourage students to formulate a basic understanding of natural phenomena and to engage in logical thinking; both processes are based on intersecting concepts of STEAM. Although the term STEAM is not mentioned in the Saudi version of the SELS statement, the concepts presented within it articulate the major content areas of scientific thinking as developmentally appropriate practices. However, the statement presents the pedagogical practices for each discipline separately, with no guidelines for teachers to identify any type of content integration as a STEAM inquiry. Notably, following the release of the SELS statement in 2015, the actual training for in-service teachers did not begin until early 2018.

A recent initiative has presented a strong incentive to promote STEAM concepts in a rich social and digital culture environment. Through a partnership between the Ministry

of Communication and Information Technology (MCIT) and the MOE (2015), the *Future Trucks* initiative has launched educational vehicles equipped with fourth industrial revolution (4IR) tools and advanced scientific materials that allow users to convert their theoretical ideas into concrete prototypes. The trucks target children and public school students, particularly those interested in digital fabrication, and their parents/guardians to introduce a STEAM approach to learning. The 4IR is a fusion of the digital, biological, and physical worlds that utilizes new digital innovations, such as the Internet of Things, robotics, and artificial intelligence (Ministry of Communications and Information Technology (MCIT), 2019, p. 120).

At the global level, the MCIT has organized the World Robot Olympiad (WRO) competition, which was held for the first time in Saudi Arabia. The competition aims to demonstrate a STEAM approach to learning through the power of digital technology; an invented pathway for educating the new generation in this technology-driven world. A large-scale partnership between the MoE, the Ministry of Energy, Industry and Mineral Resources, the King Abdulaziz City for Sciences and Technology (KACST), the Saudi Federation for Cybersecurity, Programming and Drones, the National Digital Transformation Unit (NDTU), the Saudi Wireless and Remote Control Sports Federation, and the Ensan Charity supports and sponsors 500 trainers to qualify for the competition and work with 800 teams. This massive undertaking is a part of Saudi Vision 2030, a blueprint for the digital transformation of the education sector to develop 21st-century skills and qualify Saudi youth for the future's new 4IR jobs (Ministry of Communications and Information Technology (MCIT), 2019).

The Current Study

In light of the significant and recent changes within the Saudi education system that are meant to reform its policy for and philosophy of educating young children, the aim of this study is to shed light on what Saudi teachers believe about the roles of STEAM in early childhood education. Indeed, there is a lack of research investigating early childhood teachers' beliefs about STEAM education and its applications in Saudi Arabia. Although many studies have been conducted regarding Saudi teachers and their perceptions regarding key STEAM content (e.g., Alarfaj, 2015; Aldahmash et al., 2019; Alghamdi & Al-Salouli, 2013; El-Deghaidy & Mansour, 2015; El-Deghaidy et al., 2017; Madani & Forawi, 2019), research on STEAM in Saudi early childhood education is quite limited. Therefore, the purpose of this study is to investigate Saudi teachers' beliefs about STEAM education, gaining insight into how teachers perceive and acknowledge the concept of STEAM by analyzing a set of statements. This research focuses specifically on a)

teachers' knowledge of STEAM education and b) teachers' professional training in STEAM education. The following research questions guided this investigation:

- Q1. What are Saudi early childhood education teachers' beliefs about STEAM education?
- Q2. What is the relationship between Saudi teachers' knowledge of STEAM education and their beliefs?
- Q3. What is the relationship between Saudi teachers' professional training on STEAM education and their beliefs?

Methods

A quantitative survey was used to explore Saudi teachers' beliefs about STEAM education in early childhood settings. The Committee of Research Ethics of the author's university approved this study, and an IRB approval form was obtained prior to conducting its research. All ethical guidelines were followed. Each participant provided electronic informed consent prior to accessing the survey, indicating that participation in the study was voluntary. All participants were informed that they were free to withdraw from the study at any time without fear of any retribution.

Instrument

Based on a review of empirical studies that explored the specific context of the uses of STEAM education in early childhood education (e.g., Chen et al., 2021; DeJarnette, 2018; Kang, 2019; Park et al., 2017; Simoncini & Lasen, 2018), an instrument was developed to answer the research questions. The survey used for this study was a researcher-made survey, constructed to explore Saudi teachers' beliefs about STEAM education in early childhood settings. The survey consisted of twelve items that were designed to serve as indicators of teachers' beliefs about STEAM education and its implementation in a classroom, which were accompanied by four closed-ended questions (yes/no) exploring teachers' knowledge of the concept of STEAM and teachers' professional training regarding STEAM in early education. The questions were as follows: *Have you ever heard of STEAM in early education? Have you ever used STEAM education in your classroom? Have you ever been trained in STEAM education? Have you ever attended a professional workshop/conference on STEAM education?*

The survey underwent content and context checks by experts to ensure that all items were scientifically correct and relevant. The final evaluation was performed by two academic experts; one assistant professor and one associate professor, both in the field of early childhood education. Their suggestions and corrections were incorporated into the final

version of the instrument. A peer review by faculty members who are fluent in Arabic and English was also utilized to translate the instrument items to the Arabic language. The survey was validated prior to the study using a pilot group. To check the internal consistency of the scales, a Cronbach's alpha coefficient was calculated for the total of 12 items; the coefficient was 0.905, indicating the survey's reliability. The internal validity of the survey statements was evaluated by calculating a Pearson's correlation coefficient (correlational relationship) between each item and the total scale to which it belonged. Correlation coefficients were considered statistically significant at significance levels less than (0.01) or (0.05), indicating the coherence of these items and their validity for application to the sample.

Data Collection and Analysis

The target population of this study was Saudi teachers who teach young children (3 to 6 years old) in kindergartens. An electronic copy of the survey was distributed via digital multimedia (e-mail, social media, teachers' groups on WhatsApp, Telegram, and Twitter). Respondents were asked to indicate their level of agreement with a set of practices reflecting STEAM education's implementation in early childhood education settings. Utilizing a 5-point Likert scale, teachers were asked to rate the extent to which their beliefs agreed with each item of the survey (where 1 = Not Like Me, 2 = Not Much Like Me, 3 = Somewhat Like Me, 4 = Mostly Like Me and 5 = Very Much Like Me). The obtained data were analyzed by utilizing the Statistical Package for Social Science (SPSS) software. A descriptive statistical analysis and chi-square tests were performed to answer the research questions. To answer research question 1, we calculated the means, standard deviations, percentages, and frequencies of teachers' beliefs about STEAM education. To answer research questions 2 and 3, chi-square tests were conducted to test the associations between teachers' knowledge of STEAM education and their beliefs and teachers' professional training in STEAM education and their beliefs.

Sample Characteristics

The participants in this study were 245 early childhood teachers in Jeddah city, Saudi Arabia. All participants specialized in early childhood education. The most frequent degrees obtained were a bachelor's degree (91%) and a master's degree (8%). Teachers who taught in a public kindergarten comprised 34% of the sample, with educators in private (46%) and international (18%) kindergartens comprising the rest. Their teaching experience ranged from less than five years (29%), to more than five years (57%), to ten years or more (14%). All the participants were female, as only female

teachers can work in early education schools and kindergartens in the Kingdom of Saudi Arabia (Table 1).

Results

Research Question 1

The first research question explored teachers' beliefs about STEAM concepts in early childhood education. The majority of the teachers believed that STEAM education is needed for the new generation (87%) and that STEAM education is important for preschoolers' cognitive development (90%). They also believed that math-, science-, and engineering-related concepts and activities are developmentally appropriate for children (89%). In terms of applying their beliefs through real practices, half of the teachers enjoyed teaching STEAM topics in the classroom (50%) and felt comfortable planning and integrating STEAM topics and activities (48%). Of these teachers, only 20% believed that they incorporated different STEAM activities in the classroom at an adequate pace.

Regarding their knowledge of STEAM education, only 23% of the teachers indicated they completely understood how to integrate a variety of STEAM topics and activities into their curricula. A similar proportion (24%) of the teachers believed they had adequate knowledge of the basic strategies and relevant resources for implementing STEAM into their curricula. Less than half of the teachers (45%) reported that they did not have enough support to effectively teach and integrate STEAM concepts in their classrooms. At the same time, a high percentage of the teachers (86%) believed that they needed additional professional development to implement STEAM content effectively into their curricula. Nearly half of the sample (48%) would recommend STEAM education to their peers. In comparison, (52%) of the teachers were

Table 1 Descriptive statistics

Characteristic	n	%
Degree (n = 245)		
Diploma	1	0.4
Bachelor's	223	91.0
Master's	21	8.6
Years of experience (n = 245)		
Less than 5 years	71	29.0
More than 5 years	140	57.1
10 years or more	34	13.9
Type of school (n = 245)		
Public	85	34.7
Private	115	46.9
International	45	18.4

willing to continue using STEAM education for educating young children. The means and standard deviations of the survey's statements (items) are presented in Table 2.

Research Question 2

Research question two aimed to explore the relationship between teachers' beliefs about STEAM and their knowledge of the concept of STEAM with respect to whether they had ever heard about STEAM in early education or used it in the classroom. To address this question, we calculated the relevant frequencies and percentages and ran a chi-square test for associations. Approximately 232 teachers (95%) had heard about STEAM in early education, while only 13 teachers (5%) had not. Approximately 204 teachers (83%) had used STEAM concepts in their classrooms, while 41 teachers (16%) had not. To explore the relationship of possible association, chi-square tests were performed. They showed significant associations between teachers' beliefs about STEAM education and their knowledge regarding STEAM concepts. The results showed a significant association between teachers' beliefs in STEAM education and those who had heard of STEAM in early education ($p < 0.001$). There was also a significant association between teachers' beliefs about STEAM education and those who used it in their classrooms ($p < 0.001$) (Table 3).

Research Question 3

Research question three aimed to explore the relationship between teachers' beliefs about STEAM education and their professional training with respect to whether they had been trained in STEAM education and/or had attended a professional workshop/conference that addressed STEAM concepts in early education. To answer this question, we calculated the relevant frequencies and percentages and ran a chi-square test for associations. The results show that 118 teachers (48%) reported that they had been trained in STEAM education, while 127 teachers (52%) had not. Of those, 106 teachers (43%) had attended a professional workshop/conference that addressed STEAM concepts in early education, while 139 teachers (56%) had not. Chi-square tests were performed to explore the relationship of possible associations and demonstrated significant associations between teachers' beliefs about STEAM education and their professional training. The results showed a significant association between teachers' beliefs in STEAM education and those who had reported their professional training in STEAM education ($p < 0.001$). There was also a significant association between teachers' beliefs in STEAM education and those who reported they had attended professional workshops/conferences for STEAM in early education ($p < 0.001$) (Table 4).

Table 2 Survey of statements of teachers' beliefs about STEAM education

Statements	M	SD
1 I think STEAM education is needed for the new generation	1.66	0.693
2 I enjoy teaching STEAM topics in my classroom	2.6	0.898
3 I feel comfortable with the idea of planning and integrating STEAM topics and activities for my students in the classroom	2.63	0.907
4 I regularly incorporate different STEAM activities in my classroom	3.29	0.924
5 I completely understand how to integrate a variety of STEAM topics and activities into the curricula of major content areas	3.21	0.934
6 I have adequate knowledge related to basic strategies and supporting resources for implementing STEAM into a curriculum	3.21	0.946
7 I don't have enough support to effectively teach and integrate STEAM in my classroom	2.67	0.892
8 I need some additional professional development to implement STEAM content effectively into a curriculum	1.85	0.649
9 I believe that STEAM implementation in preschool is important for preschoolers' cognitive development	1.63	0.663
10 I believe that Math/Science/Engineering-related concepts and activities are developmentally appropriate for the students	1.64	0.667
11 I recommend STEAM education to my peers and teachers	2.57	0.950
12 I am willing to continue to use STEAM education	2.44	0.938

Table 3 Chi-square test regarding teachers' knowledge of STEAM education and their beliefs about STEAM education

Factor (teachers' knowledge)	Teachers' beliefs about STEAM education			
	Yes (n)	No (n)	Chi square	p-value
Heard of STEAM in early education	232	13	100.235	0.000*
Used STEAM education in the classroom	204	41	131.314	0.000*

*Association found at 0.05 level of significance

Table 4 Chi-square test regarding teachers' professional training and their beliefs about STEAM education

Factor (professional training)	Teachers' beliefs about STEAM education		Chi square	p-value
	Yes (n)	No (n)		
Trained in STEAM education	118	127	116.843	0.000*
Attended workshop/conference on STEAM education	106	139	113.999	0.000*

*Association found at 0.05 level of significance

Discussion

This study aimed to explore Saudi teachers' beliefs about the role of STEAM education in teaching young children in kindergarten, giving particular attention to teachers' knowledge of STEAM education and teachers' professional training in STEAM teaching. The analysis revealed overall positive beliefs about the importance of STEAM education for young children; for example, that it is needed for the new generation, that it is important for preschoolers' cognitive development, and that it is developmentally appropriate for young children. On the other hand, Saudi teachers expressed somewhat moderated beliefs regarding the implementation of actual classroom practices; for example, enjoying teaching STEAM content or feeling comfortable with planning and integrating STEAM topics and activities at adequate paces. The results also demonstrated a shortage in teachers' adequate knowledge and understanding of STEAM education. Only one-quarter of the participants believed that they completely understood how to integrate various STEAM activities into their curricula and had adequate knowledge of basic strategies for implementing STEAM concepts. The results also revealed that teachers were very familiar with the term STEAM but had limited knowledge of the integration process and basic strategies and skills needed for its implementation. A substantial proportion of the teachers who participated in this study believed that they needed additional professional development and training to effectively implement STEAM content into their curricula. The following section discusses how this study's findings contribute to the existing literature on this topic.

The present findings point to clear links between teachers' beliefs regarding their teaching knowledge, their focus on the STEAM approach, and their willingness to implement its instructional practices. Teachers in this study showed only limited knowledge of the basic skills needed to endorse professional practices in STEAM pedagogy, which resulted in their rather moderate beliefs toward the implementation of STEAM concepts in their classrooms. This finding is consistent with the findings of El-Deghaidy et al. (2017), who have reported that the limitations of teachers'

knowledge about STEAM results from them not understanding the essence of the interdisciplinary learning style structured by STEAM education. The basis for a successful STEAM implementation is teachers' capacity to integrate their knowledge of two or more STEAM subjects to produce cognitive advancements through teaching young children. However, Quigley et al. (2017) have reported that teachers are not expected to be experts in all STEAM disciplines. Nevertheless, teachers need to be professionally prepared to demonstrate the appropriate level of expertise needed to identify and locate gaps in their content knowledge, make meaningful connections relevant to students' lives, and encourage students to think in different ways. Simoncini and Lasen (2018) have argued that the concepts and beliefs of STEM that are held by early childhood professionals involve developing “habits of mind” that allow teachers to provide children who are predisposed to discovering with teaching methods that transform science, technology, engineering, and math into meaningful experiences.

Another finding from this study is Saudi teachers' need for additional professional training and development in STEAM-related knowledge and implementation practices, especially in the case of emerging teaching approaches akin to STEAM, which challenges and questions teachers' pedagogic and cognitive mastery. The findings from this study are consistent with several studies that have highlighted the importance of the professional development of STEAM teaching for its successful implementation. A study by Jamil et al. (2018) reported that teachers consistently express the need for more professional development and support during their education to effectively implement STEAM lessons and that attending a professional development conference is helpful for teachers to more effectively and independently engage in STEAM pedagogical activities on their own. Similarly, DeJarnette's (2018) findings reveal that teachers' increased engagement in professional development sessions enhances their ability to plan and implement lessons, significantly boosting teachers' confidence levels, positive dispositions and self-efficacies. Other research has related the positive impact of the STEAM approach on children's learning and concluded that teachers feel more confident when they are professionally prepared to effectively teach STEAM concepts (Wahyuningsih et al., 2020). Moreover, Chen et al. (2021) have concluded that teachers with high levels of self-efficacy have greater confidence in STEM pedagogy and consistently express the need for professional development. Bush et al. (2016) have found that well-planned professional development programs—such as the PrimeD framework (Rakes et al., 2017)—have a positive impact on teachers' ability to better integrate STEAM practices in their classrooms.

Accordingly, the effective professional development of Saudi teachers must include the theoretical foundations

and visible models of STEM integration through its cross-concepts and the practical integration skills needed to teach them (Shernoff et al., 2017). An important shortcoming for teaching STEAM content separately—with no integration—is that teacher practices are then narrowed to a “single subject” at a time rather than holistically and cognitively integrating multiple subject areas. Dell'Erba (2019) has pointed out that STEAM instruction should be clearly grounded in multiple disciplines in ways that preserve their individual integrity while facilitating the natural intersection of the whole conception. Quigley et al. (2017) have clarified three dimensions of disciplinary integration for teachers to consider when teaching STEAM concepts: interdisciplinary, multidisciplinary, and transdisciplinary integration. The transdisciplinary involves multiple disciplines and the space between them to produce new perspectives. This dimension of inquiry helps learners view the connections between relevant content and other content. The interdisciplinary uses the knowledge and skills of one discipline to engage in another. This dimension encourages a student to create new knowledge. Finally, the multidisciplinary involves knowledge and skills from more than one discipline, such as science and math (Quigley et al., 2017). In this sense, teachers' knowledge base regarding STEAM integrations and how to effectively use them is essential for an effective and strong STEAM implementation (Margot & Kettler, 2019).

The full integration of STEAM into early childhood education is a process far beyond any teacher's capacity, yet it is similar to connecting puzzle pieces to help students see the world in a meaningful way. A very important aspect of educating STEAM teachers is developing their intentional openness to new teaching and learning approaches in which the integration of content and context comprises the core of teaching. Accordingly, teachers need to develop “soft skills”, such as a tolerance that allows them to “have a comfort level with exploring uncharted territory, trying new things, adapting, and the inevitable failure that comes with experimentation” (Shernoff et al., 2017, p. 10). Another important aspect of teaching STEAM to young children is a teacher's understanding of students' needs and how to nurture their learning developmentally. In other words, a teacher's knowledge base of developmentally appropriate practices is the pipeline for implementing developmentally appropriate STEAM practices effectively (Gartrell, 2016). STEAM learning among young children must take place in an integrated way that is relative to the meaningful structure of children's age and developmental stage to maximize their thinking capacity without excluding the joy of play, discovery, and expressive art (Sharapan, 2012). The results from this study reveal that most Saudi teachers believe STEAM education is developmentally appropriate for children. However, their limited knowledge of STEAM and the mechanism of its effective implementation stand as barriers.

Conclusion

The findings from this study represent an initial exploration of early childhood teacher beliefs concerning STEAM education in Saudi Arabia. Given the range of varied beliefs among teachers concerning what and how STEAM practices can be implemented in early childhood classroom pedagogy, we must rethink what the competencies for early childhood teachers are, especially amid innovative teaching approaches such as STEAM. This raises a very important question about the current state of early childhood education programs in Saudi Arabia with respect to teachers' courses in STEAM preparation. It also draws attention to opportunities for teachers' professional development in the current workforce. Notably, most teachers in this study went to college and gained their degrees before the STEAM approach became a focus. The terminology of STEAM is new to Saudi early childhood education history, yet it is starting to gain more popularity among educators. In light of the growing national focus on new approaches to teaching young children—such as the SELS statement and STEAM concepts—a new perspective regarding early childhood education is becoming increasingly common among Saudi educators.

To move forward with STEAM education, we need to critically evaluate current teachers' practices in STEAM-related content areas, assess teachers' knowledge bases, locate shortages, and fill in gaps with proper expertise and professional development. The findings from this study will hopefully inspire professionals and decision-makers to take part in the current STEAM movement regarding young Saudi students. Considering teachers' appreciation of the importance of STEAM as a promising approach, professionals need to develop high-quality programs that allow teachers to expand their educational growth and adapt to trends and emergent innovative approaches. The current effort could be focused on the structure of teacher preparation programs and how best to support teachers as they attempt to integrate STEAM education into early childhood education classrooms. One potential proposal would be to establish a digital platform for STEAM education that supports teaching children of up to 8 years of age through early childhood education according to developmentally appropriate integrated STEAM practices (Akturk et al., 2017; Gartrell, 2016; Sharapan, 2012). Given the current movements toward digital transformation within Saudi education, a digital platform, in particular, could be made accessible to all teachers all over the kingdom to exchange their thoughts about, experiences in, and lessons learned from STEAM pedagogy.

Limitations and Future Research

This study is limited by the quantitative data resources it used to measure teachers' responses to the survey items. Further investigations that consider qualitative data are recommended, as they might reveal further explanations for teachers' responses. Rich and descriptive investigation techniques, such as interviews, would provide more in-depth information about teachers' prior knowledge, current practices, and ongoing interpretations of STEAM education. Future avenues for such research would include teachers in primary (first to third) grades to explore their beliefs about and actual practices for integrating STEAM professionally in their classrooms. Other potential studies with a similar intent could include teachers in different cities and regions throughout Saudi Arabia to explore the current status of STEAM education at the national level.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval This study has been reviewed by the Committee of Research Ethics and approved by the Institutional Review Board at Taif University.

Data Availability The data generated during current study is available upon request from the corresponding author.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Akturk, A. A., Demircan, H. Ö., Şenyurt, E., & Çetin, M. (2017). Turkish early childhood education curriculum from the perspective of STEM education: A document analysis. *Journal of Turkish Science Education*, 14(4), 16–34. <https://doi.org/10.12973/tused.10210a>
- Alarfaj, M. M. (2015). Science education in Saudi Arabia. In N. Mansour & S. Al-Shamrani (Eds.), *Science education in the Arab Gulf states* (pp. 155–168). Sense Publishers.
- Aldahmash, A. H., Alamri, N. M., Aljallal, M. A., & Bevins, S. (2019). Saudi Arabian science and mathematics teachers' attitudes toward integrating STEM in teaching before and after participating in a professional development program. *Cogent Education*, 6(1), 1580852. <https://doi.org/10.1080/2331186x.2019.1580852>
- Alghamdi, A. K. H., & Al-Salouli, M. S. (2013). Saudi elementary school science teachers' beliefs: Teaching science in the new millennium. *International Journal of Science and Mathematics Education*, 11(2), 501–525. <https://doi.org/10.1007/s10763-012-9353-0>
- Alnahdi, G. H. (2014). Educational change in Saudi Arabia. *Journal of International Education Research (JIER)*, 10(1), 1–6. <https://doi.org/10.19030/jier.v10i1.8342>
- Alyami, R. H. (2014). Educational reform in the Kingdom of Saudi Arabia: Tatweer schools as a unit of development. *Literacy Information and Computer Education Journal*, 5(2), 1515–1524. <https://doi.org/10.20533/licej.2040.2589.2014.0202>
- Burrows, A., & Slater, T. (2015). A proposed integrated STEM framework for contemporary teacher preparation. *Teacher Education and Practice*, 28(2/3), 318–330.
- Bush, S. B., Cook, K. L., Ronau, R. N., Rakes, C. R., Mohr-Schroeder, M. J., & Saderholm, J. (2016). A highly structured collaborative STEAM program: Enacting a professional development framework. *Journal of Research in STEM Education*, 2(2), 106–125. <https://doi.org/10.51355/jstem.2016.25>
- Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. National Science Teachers Association.
- Catterall, L. (2017). A brief history of STEM and STEAM from an inadvertent insider. *The STEAM Journal*, 3(1), 1–13. <https://doi.org/10.5642/steam.20170301.05>
- Chao, L. (2016). *Handbook of research on cloud-based STEM education for improved learning outcomes*. Information Science Reference.
- Chen, Y. L., Huang, L. F., & Wu, P. C. (2021). Preservice preschool teachers' self-efficacy in and need for STEM education professional development: STEM pedagogical belief as a mediator. *Early Childhood Education Journal*, 49(2), 137–147. <https://doi.org/10.1007/s10643-020-01055-3>
- DeCoito, I., & Myszkal, P. (2018). Connecting science instruction and teachers' self-efficacy and beliefs in STEM education. *Journal of Science Teacher Education*, 29(6), 485–503. <https://doi.org/10.1080/1046560x.2018.1473748>
- DeJarnette, N. K. (2018). Implementing STEAM in the early childhood classroom. *European Journal of STEM Education*, 3(3), 18. <https://doi.org/10.20897/ejsteme/3878>
- Dell'Erba, M. (2019). *Preparing students for learning, work and life through STEAM education: Policy brief*. Education Commission of the States.
- El-Deghaidy, H., & Mansour, N. (2015). Science teachers' perceptions of STEM education: Possibilities and challenges. *International Journal of Learning and Teaching*, 1(1), 51–54. <https://doi.org/10.18178/ijlt.1.1.51-54>
- El-Deghaidy, H., Mansour, N., Alzaghibi, M., & Alhammad, K. (2017). Context of STEM integration in schools: Views from in-service science teachers. *EURASIA Journal of Mathematics, Science and Technology Education*, 13(6), 2459–2484. <https://doi.org/10.12973/eurasia.2017.01235a>
- Fives, H., & Buehl, M. M. (2004). What teachers believe: Exploring beliefs about pedagogical knowledge. In *Annual meeting of the American psychological association* (pp. 1–55). American Psychological Association.
- Flinn, E., & Mulligan, A. (2019). *The primary STEM ideas book: Engaging classroom activities combining mathematics, science and D&T*. Routledge.
- Gartrell, D. (2016). Developmentally appropriate STEM: It's STREAM! (science, technology, relationships, engineering, arts, and math). *Exchange*, 229, 52–56.

- Horrace, R. (2021). STREAM into online play groups how children adapt to play in a rapidly digitized world. *International Journal of the Whole Child*, 6(1), 78–87.
- Jamil, F. M., Linder, S. M., & Steglin, D. A. (2018). Early childhood teacher beliefs about STEAM education after a professional development conference. *Early Childhood Education Journal*, 46(4), 409–417. <https://doi.org/10.1007/s10643-017-0875-5>
- Kang, N. H. (2019). A review of the effect of integrated STEM or STEAM (science, technology, engineering, arts, and mathematics) education in South Korea. *Asia-Pacific Science Education*, 5(1), 1–22. <https://doi.org/10.1186/s41029-019-0034-y>
- Madani, R. A., & Forawi, S. (2019). Teacher perceptions of the new mathematics and science curriculum: A step toward STEM implementation in Saudi Arabia. *Journal of Education and Learning*, 8(3), 202–233. <https://doi.org/10.5539/jel.v8n3p202>
- Maiorca, C., & Roberts, O. T. (2018). Informal STEM learning changing preservice teachers' beliefs. In J. N. Thomas & M. J. Mohr-Schroeder (Eds.), *Proceedings of the 117th annual convention of the School Science and Mathematics Association* (pp. 13). SSMA.
- Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *International Journal of STEM Education*, 6(1), 1–6. <https://doi.org/10.1186/s40594-018-0151-2>
- Martín-Páez, T., Aguilera, D., Perales-Palacios, F. J., & Vélchez-González, J. M. (2019). What are we talking about when we talk about STEM education? A review of literature. *Science Education*, 103(4), 799–822. <https://doi.org/10.1002/sce.21522>
- Maslyk, J. (2016). *STEAM makers: Fostering creativity and innovation in the elementary classroom*. Corwin Press.
- Ministry of Communications and Information Technology (MCIT). (2019). *MCIT annual report*. Ministry Press.
- Ministry of Education (MOE). (2015). *Saudi early learning standards (SELS): Children 3 to 6 years old*. National Association for the Education of Young Children, Tatweer Company for Educational Services.
- Mitchell, D., & Forestieri, M. (2018). *Simple STEAM: 50+ Science technology engineering art math activities for ages 3 to 6*. Gryphon House Inc.
- Moore, T. J., Johnston, A. C., & Glancy, A. W. (2020). STEM integration: A synthesis of conceptual frameworks and definitions. In C. C. Johnson, M. J. Mohr-Schroeder, T. J. Moore, & L. D. English (Eds.), *Handbook of research on STEM education* (pp. 3–16). Routledge.
- National Association for the Education of Young Children & The Fred Rogers Center. (2012). *Technology and interactive media as tools in early childhood programs serving children from birth through age 8*. NAEYC.
- National Association for the Education of Young Children (NAEYC) & National Council of Teachers of Mathematics (NCTM). (2002). *Early childhood mathematics: Promoting good beginnings*. NAEYC.
- National Research Council (NRC). (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Committee on a conceptual framework for New K-12 science education standards. Board on Science Education, Division of behavioural and social sciences*. The National Academies Press.
- National Science Teachers Association (NSTA). (2014). NSTA position statement: Early childhood science education. *Science and Children*, 51(7), 10–12.
- NGSS Lead States. (2013). *Next generation science standards: For states, by states*. National Academies Press.
- Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307–332. <https://doi.org/10.3102/00346543062003307>
- Park, M. H., Dimitrov, D. M., Patterson, L. G., & Park, D. Y. (2017). Early childhood teachers' beliefs about readiness for teaching science, technology, engineering, and mathematics. *Journal of Early Childhood Research*, 15(3), 275–291. <https://doi.org/10.1177/1476718x15614040>
- Quigley, C. F., Herro, D., & Jamil, F. M. (2017). Developing a conceptual model of STEAM teaching practices. *School Science and Mathematics*, 117(1–2), 1–12. <https://doi.org/10.1111/ssm.12201>
- Rakes, C. R., Bush, S. B., Mohr-Schroeder, M. J., Ronau, R. N., & Saderholm, J. (2017). Making teacher PD effective using the PrimeD framework. *New England Mathematics Journal*, 50(1), 52–63.
- Ramírez-Montoya, M. S. (2017). *Handbook of research on driving STEM learning with educational technologies*. IGI Global.
- Raths, J. (2001). Teachers' beliefs and teaching beliefs. *Early Childhood Research & Practice*, 3(1), 87–135.
- Saldaña, D. I. (2018). *STEM play experiences in early childhood*. Apple Books.
- Sharapan, H. (2012). From STEM to STEAM: How early childhood educators can apply Fred Rogers' approach. *Young Children*, 67(1), 36–40.
- Shernoff, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education. *International Journal of STEM Education*, 4(1), 13. <https://doi.org/10.1186/s40594-017-0068-1>
- Simoncini, K., & Lasen, M. (2018). Ideas about STEM among Australian early childhood professionals: How important is STEM in early childhood education? *International Journal of Early Childhood*, 50(3), 353–369. <https://doi.org/10.1007/s13158-018-0229-5>
- Sousa, D. A., & Pilecki, T. (2013). *From STEM to STEAM: Using brain-compatible strategies to integrate the arts*. Corwin Press.
- Valcke, M., Sang, G., Rots, I., & Hermans, R. (2010). Taking prospective teachers' beliefs into account in teacher education. *International Encyclopedia of Education*, 7, 622–628. <https://doi.org/10.1016/b978-0-08-044894-7.00668-0>
- Vartuli, S. (2005). Beliefs: The heart of teaching. *Young Children*, 60(5), 76–86.
- Wahyuningsih, S., Nurjanah, N. E., Rasmani, U. E. E., Hafidah, R., Pudyaningtyas, A. R., & Syamsuddin, M. M. (2020). STEAM learning in early childhood education: A literature review. *International Journal of Pedagogy and Teacher Education*, 4(1), 33–44. <https://doi.org/10.20961/ijpte.v4i1.39855>
- Wang, H. H., Moore, T. J., Roehrig, G. H., & Park, M. S. (2011). STEM integration: Teacher perceptions and practice. *Journal of Pre-College Engineering Education Research*, 1(2), 2. <https://doi.org/10.5703/1288284314636>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.