

# Science and Mathematics Teachers' Views of STEM Integration in an International School

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## Abstract

Education in the STEM fields science, technology, engineering, and mathematics—is becoming increasingly acknowledged as the cornerstone of socio-economic growth, economic competitiveness, and national growth. This qualitative study explores the STEM integration views of science and mathematics high school teachers. Their number was four teachers who possess certification as a secondary school teacher in mathematics or science, are actively engaged in teaching at the secondary school level and hold a strong belief in the implementation of curricular integration within their classroom, in an international school in Dubai. The results indicate that project-based learning (PBL) is the most common STEM integration approach. The benefits associated with PBL include increases in student engagement and motivation, as well as improvements in achievement related to group work and personalization of learning. Teacher STEM pedagogical content knowledge was identified as a useful construct in assessing teacher needs. The four significant findings are: 1) project-based learning forms the foundation of STEM integration; 2) teachers believe that there will be an improvement in achievement for those students enrolled in STEM programs; 3) field trips and partnerships represent a powerful tool in complementing PBL approaches to STEM integration; and 4) STEM integration through PBL approach requires additional time for teachers.

## Keywords

Project-Based Learning, Curriculum Integration, STEM

## 1. Introduction

### 1.1. Background

Currently, in United Arab Emirates schools, most of the curriculum is taught in

subject-specific classes with little cross-disciplinary collaboration or coordination of subject matter. Curriculum integration, in general, is a pedagogical approach that encourages teachers to combine two or more subject areas and relate learning to “real-life” situations. From a theoretical perspective, curriculum integration is founded on the constructivist view that knowledge is constructed through investigation and social interaction, which ideally takes place in real-world interdisciplinary and interconnected contexts [1]-[5]. Traditional learning in the United Arab Emirates makes students more isolated and limits their ability to be more knowledgeable about interconnection. Stem integration, technology, science, and mathematics increase and promote the students’ practical learning experience [2]-[4]. Also STEM integration subjects and educators enhance various skills such as problem solving, make them more active in the classrooms and prepare them to be more effective in work environment. To date, some research has shown that students in integrated programs outperform students in traditional discipline-based programs [6]. Many researchers propose that the curriculum integration design has the potential to meet these multifaceted objectives; however, a lack of uniformity in the definition and implementation strategies has made its enactment by practitioners! complex [7]. There is a renewed interest in approaches to integrating curriculum and a particular interest in STEM integration, which focuses on integrating science, technology, and mathematics. Declining mathematics and science test scores on international comparisons, such as the Program for International Student Assessment (PISA), the need to compete in a technologically expanding global economy, and calls for an engaging and relevant curriculum have led to this renewed interest in STEM education and the need for investigations into how progressive teachers are implementing this approach [8]-[13]. The increasing focus on STEM makes it essential to remember that project-based learning is a successful teaching strategy in STEM programs. Project-based learning is successful in STEM because it emphasizes collaborative learning and teamwork in conducting investigations, evaluating hypotheses, and creating artifacts [14].

It is an instructional strategy emphasizing student interest, experiential learning, inquiry, and critical thinking and deemphasizing memorization and singular correct answers [15]-[18].

## **1.2. Statement of the Problem**

Many researchers and educators recognize the value of curriculum integration through its potential to engage students and improve learning [19]-[21]. Consequently, many educators and researchers have been interested in restructuring subject matter delivery from discipline-specific courses to a more holistic and interdisciplinary format [19] [20] [22]. These factors make it challenging to create preservice and in-service professional development programs that are both pertinent and useful, which presents difficulties for practitioners trying to put into practice instructional strategies that would otherwise be successful. Researchers

are encouraged to explain more teacher practices that support interdisciplinary, multidisciplinary, and cross-disciplinary instruction and the effects of these practices on student learning [13]. English (2017) notes that research on integrated STEM education that has already been done needs to provide more information about the curriculum or program being used, including the kind of integration that is used and the means of support [23]. In response to these calls, this study contributes to the theoretical and practical understanding of curriculum integration, specifically STEM integration, by comprehensively describing high school teachers' views and knowledge of integrating curriculum.

### 1.3. Purpose of the Study

This qualitative study explores the views of math and science high school teachers of STEM integration in an International School in Dubai.

### 1.4. Research Question

What insights can be gained from exploring the views of mathematics and science high school teachers' view of STEM integration?

### 1.5. Significance of the Study

The study aligns with the UAE's agenda to enhance the quality of education and increase its global competitiveness. Over the past decade, as the United Arab Emirates transitioned to a knowledge-based country, the UAE has prioritized efforts to support education as the backbone of a modern economy. Preparing today's students with a world-class education will give them the skills necessary to participate fully in future development. The goal of the UAE is to assess and benchmark the performance of its students in critical subjects such as mathematics, reading, and science by being one of the 20 top countries in PISA scores.

## 2. Theoretical Framework

The topic of curriculum integration has existed for more than 100 years and can be traced back to John Dewey and constructivist learning theory [2]. Dewey (1916, 1938) believed knowledge is constructed through investigation and social interaction in real-world interdisciplinary contexts [3] [4]. Curriculum integration approaches, such as STEM integration, address these contexts and use students' prior knowledge as starting points for investigation [24]-[26]. Curriculum integrators stress active learning regardless of the approach. Bonwell and Eison (1991) state that anything involving pupils practicing and analyzing tasks is considered active learning [27]. All involve students working in groups to optimize its benefits. Curriculum integration encourages active learning [25]. Honey *et al.* (2014) define problem-based learning as an experiential educational technique that engages students in loosely organized challenges that mimic real-life circumstances to stimulate active learning [28].

## 2.1. Situated Learning

Situated learning theory, often referred to as situated cognition theory, holds that contexts, which include the social and physical elements of a learning activity, are essential to the learning process [9] [29] [30]. Consequently, the knowledge acquired is linked to the circumstances or context in which it was acquired [31]. Thus, while introducing knowledge to students, it is best to employ authentic settings, circumstances, or experiences they can relate to [32]. Curriculum integration techniques place students in a context that blends pertinent activity within a collaborative environment, making learning authentic (Figure 1).

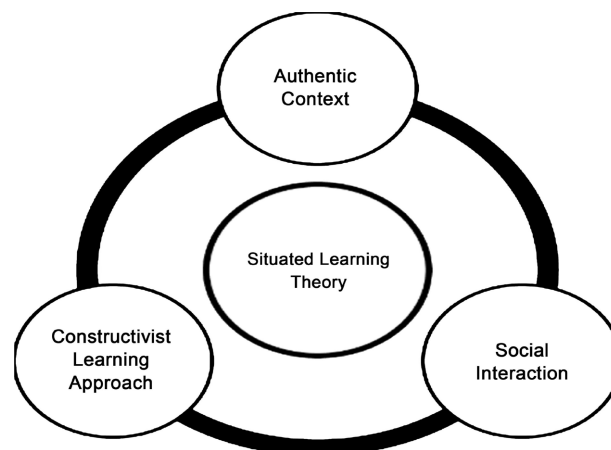


Figure 1. Situated learning theory framework.

## 2.2. Social Development Theory

Social development theory stresses the fundamental role of social interaction in the development of cognition [33]. According to the theory, learning is a social process through student interaction whereby students negotiate for meaning and internalize it into their cognitive structures. This theory asserts three significant themes regarding social interaction: 1) learning occurs firstly due to social interaction, after which students internalize learning on an individual level; 2) all individuals can learn from a More Knowledgeable Other (MKO). The MKO is someone with a higher skill level than the learner. The MKO can be a teacher, a parent, a peer, or an electronic device; and 3) learning occurs in the Zone of Proximal Development (ZPD), which is the point the learner is capable of reaching under the guidance of an MKO, which may include use of the scaffolding strategy [34].

## 2.3. Conceptual Framework

Integrated STEM education has many definitions, but modern approaches have specific traits [35]-[37]. According to Moore *et al.* (2014), STEM integration involves integrating all or part of the four disciplines into a single lesson, unit, or class that addresses real-world concerns [38]. It is a method of teaching STEM courses that span two or more STEM domains and are limited by STEM practices in the real world to improve student learning [9]. Table 1 shows how educators

might use these two theories together as it combines Moore *et al.*'s (2014) six tenets and eight fundamental features [38] with LaForce *et al.*'s (2016) 76 critical STEM school qualities [39] (**Table 2**). Framework linkages drove data analysis.

**Table 1.** Comparison of frameworks.

LaForce <i>et al.</i> (2016)	Moore <i>et al.</i> (2014)
Core-Instructional Elements	Six Tenets
Sub-Categories	
Problem-based Learning	Motivating and Engaging Context Emphasis on Teamwork and Communication Learning from Failure through Redesign
Rigorous Learning	Inclusion of Mathematics and/or Science Content
Personalization of Learning	Student Centered Pedagogies Motivating and Engaging Context
Career, Technology, and Life Skills	An Engineering Design (use of appropriate technology) Emphasis on Teamwork and Communication
Sub-Categories <sup>1</sup>	
School Community and Belonging	
- Strong school culture	
External Community	
- Establishing relationships with community institutions	
Staff Foundations	
- Staff collaboration	
- School leader supports staff growth and development <sup>1</sup>	
Essential Factors	
- Staff Attitudes, belief that all students can learn	

From LaForce *et al.* (2016). 76 characteristics of successful schools.

## 2.4. Literature Review

### 2.4.1. Standards Methods for Integration Curriculum

No curriculum integration framework exists, yet diverse designs or approaches have similarities. Kelley & Knowles (2016) use Vasquez, Sneider, and Comer's (2013) three-stage structure to integrate multidisciplinary, interdisciplinary, and transdisciplinary techniques [9] [40] (**Figure 2**). This three-stage continuum's disciplines become more interdependent [9].

"True" or "pure" curriculum integration is issue-based education or curriculum negotiation. It assumes disciplines are social constructs, making distinctions

meaningless. Gun control, climate change, social justice, and personal development are covered this way. Beane and Fraser propose transdisciplinary curricular integration as a democratic pedagogy that prepares students for global citizenship. Teachers must alter their planning and draw from their collective discipline knowledge to introduce curriculum objectives instead of scheduled individual sessions. The transdisciplinary method is based on constructivism, a psychology and human development model emphasizing active learning. It values learners' experiences and perspectives and promotes multidisciplinary collaboration. It values learners' experiences and perspectives and promotes multidisciplinary collaboration (Figure 3).

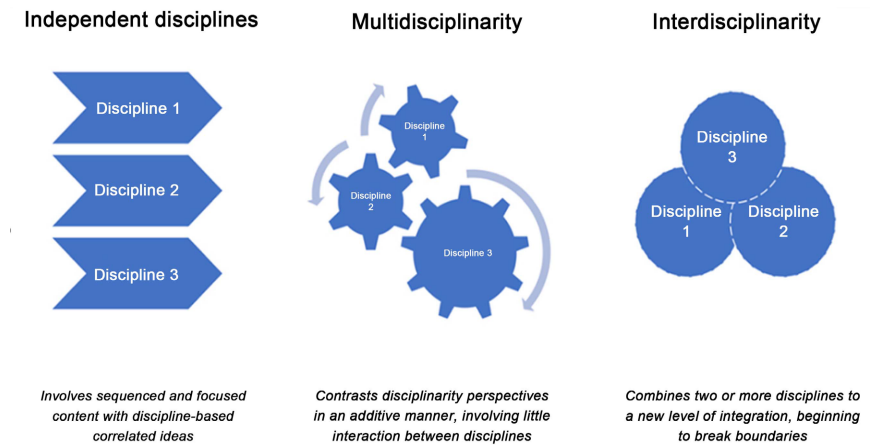


Figure 2. Standards methods for integration curriculum.

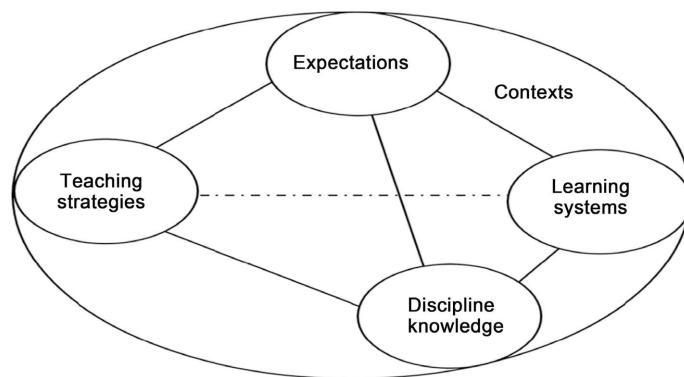


Figure 3. Examples of methods for integration curriculum.

### 2.4.2. STEM Integration

STEM integration refers to teaching STEM subjects in a real-world setting, where the content from many STEM domains is combined to promote student learning. This approach aims to connect different disciplines and improve the educational experience for students [9] [37]. STEM integration initiatives aim to align closely with a transdisciplinary approach to curriculum integration. However, the actual implementation may resemble either multidisciplinary or interdisciplinarity approaches, depending on the extent to which thematic or authentic (real-world

problems) elements are incorporated [9] [40] [41].

Additionally, STEM integration aims to generate interest in STEM careers. Furthermore, the implementation of STEM integration and its student-centered collaborative practices is being seen as a means to promote greater participation of females in post-secondary STEM programs, therefore aiding in the reduction of the gender disparity in STEM employment [41]-[43]. The increase in interest in STEM education has resulted in the development of diverse implementation and investigative frameworks to guide instructors in properly integrating STEM courses (Table 2).

**Table 2.** Comparison of frameworks.

Core-Instructional	Core Non-Instructional	Supporting Elements
Problem-based Learning	School Community and Belonging	Staff Foundations
Rigorous Learning	External Community	Essential Factors
Personalization of Learning		
Career, Technology, and Life Skills		

Eight Essential Elements of Inclusive STEM High Schools (LaForce *et al.*, 2016).

To improve student learning of math and science by using an engineering design-based approach for integrated STEM, Dare *et al.* (2018) conducted a multiple-case study of nine American middle school science teachers to learn more about these teachers' experiences in developing and implementing integrated STEM curricular units in their science classrooms [9] [38]. The results of this study show that, to differing degrees, the participants found it challenging to relate arithmetic, science, and engineering explicitly. The majority concentrated on teaching science, then math, and finally attempted to incorporate engineering or real-world elements.

The UAE has teamed up with international organizations and educational institutions to use the best practices in STEM education. These partnerships use foreign knowledge and experiences to raise the standard of STEM education in the nation. There have been initiatives to raise public awareness of the importance of STEM education. Campaigns and community outreach initiatives aim to inform parents, students, and the general public about the benefits of STEM fields and their potential for employment [6] [10] [41] [44].

### 2.4.3. Benefits of Integration

Several studies describe the benefits to student learning when teachers employ a curriculum integration approach [45] [46]. One of the most commonly cited benefits of integration is that by encouraging teachers to connect multiple subject areas in a unified manner, curriculum integration makes learning relevant and engaging [9] [36] [47]. On the other hand, other studies find that increases in

achievement are more focused [45] [46] [48]. These studies note that the achievement of African American, Hispanic, female, and socioeconomically disadvantaged individuals, in particular, benefit from STEM integration, while the achievement of white socioeconomically stable students shows marginal improvement.

### 3. Research Design

A constructivist worldview meaningfully complements the qualitative technique in qualitative research, which often employs an inductive approach to complicated situations where complexity and human perception shape how the data is examined [49]. Furthermore, qualitative research is less helpful in documenting participant viewpoints and personal interpretations regarding everyday events or investigating unique phenomena [50]. The exploratory nature of the research question and the fact that there are relatively few secondary school teachers currently practicing various forms of curriculum integration make it particularly difficult to solicit an ample amount of quantitative data for analysis [51] [52].

#### 3.1. Study Method

Since the study generally aims to comprehend people and how they make sense of the world [50] [53], a qualitative approach to inquiry was selected. More precisely, the study focuses on investigating and comprehending the perspectives and beliefs of teachers [50]. Semi-structured interviews were conducted using six open-ended questions pertinent to the study's objectives to collect qualitative data. The researcher interviewed four high school teachers, who asked them to discuss their opinions and ideas regarding STEM integration. After that, the participants' opinions are gathered by documenting their responses to open-ended questions [49] (Table 3).

**Table 3.** Research methodology.

Research question	Tools and Instruments	Data Collection	Methods of Analysis
What insights can be gained from exploring the beliefs and opinions of teacher participants on the impact of integrating mathematics, science, engineering, and technology on student learning and achievement?	Semi-structured Interviews	Qualitative	Thematic Analysis Conceptualization, classifying, organizing, and describing themes

#### 3.2. Site

Improving teaching and professional learning to support learning better is, according to policymakers and educational leaders, the key to reforming education for prosperity in the United Arab Emirates. In Dubai, United Arab Emirates, at a

K–12 American school, the study was carried out.

### 3.3. Population, Sampling, and Participants

Four individuals indicated their willingness to participate in the study: two educators from the mathematics department and two from the science department. This study employed a purposive sampling strategy to select information-rich cases [49]. The goal of this exploratory study was gaining an in-depth understanding of the experiences of teachers actively engaged in STEM integration. The four participants were selected specifically because they were identified by school leadership as pioneers of STEM integration within their departments. While small, this sample size was appropriate for the study's scope, as thematic saturation was approached during the analysis; recurring patterns in teacher beliefs, implementation strategies (PBL), and perceived benefits began to emerge across the four interviews, suggesting that additional participants from this specific context would yield diminishing returns in terms of novel themes.

### 3.4. Instruments

Six open-ended questions relevant to the study's goal were used in semi-structured interviews to gather qualitative data.

Semi-structured interviews should assess teachers' responses to the research phenomena. When objective rather than personal information regarding an event or occurrence is provided, semi-structured interviews are somewhat in-depth [54]. Their interview agenda included central and follow-up questions. These questions needed to be open-ended to encourage spontaneous responses and conversation.

Teacher Interviews. Semi-structured one-on-one interviews were scheduled at each teacher's convenience. The interviewing process adhered to Merriam's (2009) criteria [55], with pre-planned questions that allowed for flexible questions to elicit fresh insights and a combination of semi-structured and specific questions to which specific data were sought. During the interview, preliminary information was gathered, and the participants:

- 1) Background in education, teaching, and other pertinent experiences.
- 2) Present comprehension of the nature of STEM integration.
- 3) An explanation of their approach to curriculum integration in the classroom.
- 4) Views of the impact of STEM integration on students' education.

### 3.5. Data Analysis

The study's qualitative data analysis adhered to the guidelines provided by Braun and Clarke (2013) for identifying and deciphering meanings present in qualitative data [56].

This phase involved transcribing qualitative data and evaluating to using it through thematic analysis. Individual interviews were fully transcribed using an AI program, and it was crucial to balance the transcription's accuracy, and the

amount of time allotted for analysis [57]. The researcher paid more attention to the substance than to accurately translating every emotion heard in the audio recording; for example, the researcher left out the words “mmm” and “hmm” [58]. The researcher read the transcripts multiple times to ensure they were accurate, and that the researcher was not assuming anything about the facts or what the researcher knew [59]. According to Hyde, Ryan, and Woodside (2013), transcription made it possible to comprehend the context and substance of each interview better and helped uncover some early trends [60]. There were no objections noted. A thematic analysis was used to analyze the interviews. An inductive approach was used to identify emergent themes directly from the data, then deductive layer of analysis was conducted. The emergent themes were systematically mapped against the key tenets of the conceptual framework, specifically the “Six Tenets” of Moore *et al.* (2014) and the “Core-Instructional Elements” of LaForce *et al.* (2016). For example, codes related to hands-on activities and student motivation were analyzed through the lens of Moore *et al.*'s “Motivating and Engaging Context”, while codes concerning teacher collaboration and beliefs were connected to LaForce *et al.*'s “Staff Foundations” and “Essential Factors”. This two-step process ensured that the analysis was grounded in the participants’ unique experiences and structured by established theoretical constructs, strengthening the connection between the data and the conceptual framework (Table 4).

**Table 4.** Braun and Clarke’s (2013) six phases of thematic analysis.

Six Phases of Thematic Analysis	Description
Familiarization with the data	The researcher read the data again and again
Coding	The researcher generated pithy labels for the data, known as an analytic approach.
Searching for themes	The codes identified themes
Reviewing themes	Checked to make sure the themes are about both the literature and the data
Defining and naming themes	Each theme was identified to construct a concise and informative name for each theme.
Writing up	Finally, analytic narrative and data extracted

### 3.6. Validity and Reliability

Validity and reliability tests for research tools are essential [49]. According to Johnson & Christensen (2017), a question’s validity is determined by how well it measures the intended outcome to extrapolate the results. The validity of inquiries, format validity, and content measures are examples of validity testing [50]. A university professor approved the interview questions used in the qualitative section and the exam used in the quantitative section. The professor proposed altering a few elements to guarantee the validity of the instruments employed in this study.

### 3.7. Ethical Consideration

Always examine research ethics before starting [61]. Gajjar (2013) states that ethical research practices validate objectives, including originality, reliability, and anomaly avoidance [62]. The researcher encouraged the high school's science head and vice principal to apply moral principles to the probe. The researcher briefly presented the study's goals and methods at their school meeting. The British University in Dubai sent the school's management a letter requesting permission to undertake this research. The researcher kept student identities anonymous. The school's name persuaded the administrators that the material would be kept private and used for research [49]. The school admission participants were told they could exit the research without penalty. The volunteers can exit this experiment at any moment if they feel comfortable. They also heard that their trust and honesty would be valued. We considered all suggested ethical standards during our evaluation, stressing any flaws the school management has acknowledged. Data analysis and findings follow data gathering in the next chapter.

## 4. Results

### 4.1. Teacher Views and Understanding of STEM Integration

A science teacher prefaces her explanation of STEM integration, suggesting that it is "rudimentary" and based upon limited professional development opportunities. She encapsulates her understanding of STEM integration through an example: The natural reasoning process occurs among some or all subjects [science, mathematics, and technology] when someone investigates a phenomenon or issue like climate change. You cannot investigate climate change without diving into science or biology and using some relevant mathematics to do this. Then, in many ways, you may look at emerging technologies to help mitigate pollution. So, this is all connected, and that is how I see STEM.

Another teacher describes himself as having a powerful command of mathematics yet little experience integrating science, technology, and mathematics. He explains that he sees STEM integration as the "combination of science, technology, and mathematics...or at least any two of these in one semester or school year." He believes that STEM integration can lead to a more in-depth and connected understanding of various scientific phenomena than the narrower subject-specific approach to learning with which many educators are more familiar. The teacher states:

I see all the connections and the benefits of going more profound or broader instead of just focusing on the math skills or, in the case of science, just doing the science behind it. So, can we connect them? Yes, I would like to see more of that.

The third teacher says that he understands STEM integration as both an avenue for more comprehensive learning and for greater engagement of students. He adds that it is not only the students who may benefit from an integrated approach to instruction but teachers as well, saying: "I think that [STEM integration] would be a way for me to keep the interest in integration and teaching in general, learning

to present material in a new way which may benefit all of us.”

On many occasions, one of the teachers refers to himself as a “problem-solver” with a passion for developing solutions to novel problems. He sees STEM integration as an opportunity for teachers to implement a realistic approach to learning that investigates real-life problems using a systematic and logical method. This method is based upon the engineering design process that incorporates all of the STEM disciplines, enabling people to define and divide a project or problem into steps. Curtis enthusiastically explains: “I love to take a problem and break it down into manageable steps, that is what I do... and I see that [problems] everywhere, just all sorts of opportunities to improve things”.

#### **4.2. Teacher’s Approach to Integration**

The teacher’s approach to integration is founded upon their belief that learning is a social activity and that “interdependence at a young age is essential for their student’s learning.” Elaborating on this idea, teachers explained that, throughout their teaching careers, they have gradually promoted more and more group work based on the notion that collaboration among students is a valuable learning component. They mentioned that because most of what they have learned about integration has involved group work and students working in teams, they became increasingly enthusiastic about implementing some form of integration in their classroom. They explained that, ideally, they would like to implement an entirely project-based form of STEM integration; however, because they found it difficult to develop relevant curriculum-linked activities, they have had to rely on a mixture of textbooks and collaboratively developed problem- and project-based activities for their students. The projects they have created revolve around central themes based on mathematical and scientific concepts and most closely align with a project-based interdisciplinary approach to integration. Project-based learning has the unique ability to spark and sustain a lifelong interest in STEM. When students see the impact of their projects and understand the relevance of STEM concepts in their lives, they are more likely to pursue further education and careers in STEM fields. This approach lays the foundation for future innovators and problem solvers.”

In the 21st century, thinking critically, working with others, and adjusting to new situations are very important. Project-based learning fits these skills perfectly for the 21st century. We prepare students for STEM jobs and the needs of a constantly changing world by giving them projects like real-life problem-solving situations.

#### **4.3. Benefits of STEM integration**

Teachers believe that the STEM integration approach has resulted in several benefits to student learning and achievement; they associate these benefits with the projects the students participate in and attribute this to the relevant and real-life contexts for learning.

Math and science teachers believe integrating science and mathematics through real-life problems and projects benefits students by promoting engagement and motivation. Jacob explains that motivating and engaging mathematics and science students at the applied level of grades 9 and 10 is often challenging. Relevant, real-life projects that include computer research, group work, and hands-on activities “allow them to make connections between classwork and real-life experiences.” In doing so, “students see a better reason for learning math and science...which I find engages and motivates them on a far higher level than our regular [subject specific] classes might” and “STEM integration improves student achievement by contextualizing learning. When students see how science, technology, engineering, and math concepts apply to real-world problems through hands-on projects, they gain a deeper understanding. This practical application enhances retention and comprehension, improving academic performance.”

#### 4.4. Findings

The study question addressed semi-structured interviews and journal entry findings. These conversations cited STEM integration literature. Where applicable, the findings will be related to Moore *et al.*'s (2014) six central pillars for successful STEM education [38] and LaForce *et al.*'s (2016) eight critical features of inclusive STEM high schools [39]. Next will be a discussion of the findings' implications and research suggestions. The chapter ends with some reflections.

### 5. Discussion: Research Question

Understanding participants' STEM integration views is crucial to understanding their path toward integration. These teachers believed in the benefits of STEM integration and modifying their teaching techniques. Each participant wants to start STEM integration education because they believe it works. All participants base their STEM integration approach on motivating and engaging students and improving student outcomes. STEM integration is often seen as a top-down initiative driven by corporate, political, provincial, and Board of Education needs and policies [9], but these educators' accounts suggest a grassroots or personal motivation facilitated by institutional initiatives and policies. These educators claimed that STEM integration was not an organizational requirement.

The participants' belief that STEM integration can engage, motivate, and improve learning is founded on the participants' pedagogical views that STEM integration aligns with constructivist learning theory and an inquiry-based approach to instruction. Consequently, all expressed the opportunity for students to engage in inquiry-based learning and group work as another benefit associated with STEM integration. These views align with Zhang *et al.* (2023), who note the links between a constructivist mindset and effective implementation of inquiry-based instruction initiatives [63]. Teacher beliefs translate into a commitment to their integration efforts, as they all exhibit a passion and desire to improve the experiences they will provide for their students. This finding is in agreement with the

work of Lesseig *et al.* (2019) and Ring *et al.* (2017), who point to the success of any STEM integration initiative as a function of the beliefs of the teacher: To be resilient in their commitment to adopting integrated STEM education, teachers must have strong confidence that integrating curriculum is what is best for their students [36]. Each participant noted that their efforts to provide a positive integrative belief for their students are an ongoing and evolving endeavor that requires time, collaboration, and professional development.

The participants' constructivist beliefs about learning and instruction correspond to LaForce *et al.*'s (2016) supporting elements essential factors, which notes the role of staff attitudes as playing an instrumental role in STEM implementation. More specifically, all participants relayed the belief that "all students can learn" [39], when supported by social learning practices such as peer interaction and collaborative learning.

Their views also coincide with three of the principles put forth by Moore *et al.* (2014): 1) an inspiring and stimulating environment, 2) centered around students' methodologies, and 3) a focus on communication and collaboration [38]. As a motivator of integration, Moore *et al.* (2014) contend that when teacher beliefs incorporate these three tenets, they are more likely to adopt an STEM integration approach to instruction where students engage in hands-on activities and discovery-based tasks, notably constructivist viewpoints [38]. The project-based approaches of these educators incorporated each of these three tenets.

All participants believed that a project-based approach was the foundation of STEM integration, noting that project-based learning (PBL) can provide a context for learning that meets their criteria of engagement and motivation. This teaching strategy allows teachers to identify relevant curriculum expectations and provide context for integrating the disciplines. Each participant expressed the importance of developing projects that were relevant in terms of having "real-life" meaning and that were embedded with curriculum-related problems.

Engagement and motivation represent a significant theme throughout the study. As discussed earlier, all participants consider engagement and motivation as the impetus of their STEM integration approaches, and any benefits associated with their approach are seen as "byproducts" of engaged and motivated students. All participants reported that introducing projects that students could relate to or that were broad and flexible enough to be personally relevant stimulated engagement and motivation, thereby improving student learning. The most commonly reported benefits associated with student learning were increased retention of mathematical and science-related concepts. These increases were attributed to contextual projects leading to the 171 students' ability to link concepts to concrete products or artifacts and a desire for deeper analysis of topics. Linda reported that learning concepts in greater depth led to students remembering the concepts. David found that the interdisciplinary connections embedded in a PBL approach enable students to focus and retain better. The participants connected engagement and motivation with student opportunities to investigate concepts of personal in-

terest. This flexibility to personalize learning is another benefit to student learning associated with STEM integration and a PBL approach. The participants consistently reported this benefit; however, the flexibility to personalize learning depends upon the projects' broadness, constraints dictated by curriculum targets, the participant's STEM pedagogical content knowledge, and the number of integrated courses.

### **5.1. Implications and Recommendations**

Provincial and board-supported professional development for administrators should include an overview of STEM integration approaches like PBL, options for adjusting and offering flexible timetabling to permit the coordination of integrated courses and participant teachers, information on how to provide the best additional resources that STEM programs may require, like additional field trips, and time for collaborative experiences. This will raise school administrators' awareness of how to support the best teachers who wish to implement a STEM integration approach in their schools.

### **5.2. Limitations**

Time constraints hampered data gathering and processing in this study. Due to these constraints, the study's scope limited its ability to capture long-term changes. Future studies should have a longer-term view to overcome this barrier and explore more deeply. Using elementary, middle, or high school levels limits the study's relevance to other educational levels. This emphasis must be examined to determine how it affects the findings' applicability to education. Discussions should also address how the study's findings apply to similar educational situations and suggest further research across educational levels. Examining teachers' attitudes requires careful examination of school rules and resources. Describing the study's context is essential for outcome applicability. Explore how findings might be generalized to similar situations and suggest further research in varied settings to understand contextual influences better. The study's findings are context-specific and should be interpreted with caution regarding generalizability. The research was conducted in a single, private international school in Dubai, a setting with distinct characteristics that may not be representative of other educational environments, such as public schools within the UAE or schools in different countries. Factors unique to this context include potential access to greater financial and technological resources, a higher degree of curricular autonomy compared to state-regulated public schools, and a diverse student body often from socio-economically advantaged backgrounds. The facilitators (e.g., flexible scheduling for PBL) and barriers identified by these teachers may differ significantly from those experienced by educators in more resource-constrained or bureaucratically rigid systems. Future research should explore teacher views on STEM integration in public schools to provide a comparative perspective. A thorough review of how this constraint affects the study's external validity is needed. Encourage future re-

search to use more extensive and diverse samples to improve generalizability and robustness.

Also, this study depends on self-reported data from teacher interviews which is effective for capturing teacher views, beliefs, and perceptions, but it is subject to potential self-report bias. There can be a discrepancy between what practitioners say they do (espoused theory) and their actual classroom practices (theory-in-use). The findings reflect the teachers' understanding and interpretation of their work, but do not include objective measures of classroom implementation or student outcomes. To build upon these findings, future research could employ a mixed-methods approach that triangulates interview data with classroom observations, analysis of curricular materials, and student achievement data to provide a more holistic and validated account of STEM integration in practice.

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### Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

### References

- [1] Ahmad, S.F., Han, H., Alam, M.M., Rehmat, M.K., Irshad, M., Arraño-Muñoz, M., *et al.* (2023) Correction: Impact of Artificial Intelligence on Human Loss in Decision Making, Laziness and Safety in Education. *Humanities and Social Sciences Communications*, **10**, Article No. 361. <https://doi.org/10.1057/s41599-023-01842-4>
- [2] Beane, J. (1996) On the Shoulders of Giants! The Case for Curriculum Integration. *Middle School Journal*, **28**, 6-11. <https://doi.org/10.1080/00940771.1996.11496182>
- [3] Dewey, J. (1916) *Democracy and Education: An Introduction to the Philosophy of Education*. Macmillan.
- [4] Dewey, J. (1938) *Experience and Education*. Macmillan.
- [5] Morrison, J., Frost, J., Gotch, C., McDuffie, A.R., Austin, B. and French, B. (2021) Teachers' Role in Students' Learning at a Project-Based STEM High School: Implications for Teacher Education. *International Journal of Science and Mathematics Education*, **19**, 1103-1123. <https://doi.org/10.1007/s10763-020-10108-3>
- [6] Al-Balushi, A. and Ambusaidi, A.K. (2023) Investigating Omani Preservice Science Teachers' Attitudes and Intentions to Integrate Coding and Robotics. In: Al-Balushi, M., Ambusaidi, A.K., Al-Haj, K.D. and Al-Harthy, Z.K., Eds., *Reforming Science Teacher Education Programs in the STEM Era*, Springer, 293-311.
- [7] Khalil, R.Y., Tairab, H., Qablan, A., Alarabi, K. and Mansour, Y. (2023) STEM-Based Curriculum and Creative Thinking in High School Students. *Education Sciences*, **13**, Article 1195. <https://doi.org/10.3390/educsci13121195>
- [8] Habig, B. and Gupta, P. (2021) Authentic STEM Research, Practices of Science, and Interest Development in an Informal Science Education Program. *International Jour-*

- nal of STEM Education*, **8**, Article No. 57.  
<https://doi.org/10.1186/s40594-021-00314-y>
- [9] Kelley, T.R. and Knowles, J.G. (2016) A Conceptual Framework for Integrated STEM Education. *International Journal of STEM Education*, **3**, Article No. 11.  
<https://doi.org/10.1186/s40594-016-0046-z>
- [10] Eltanahy, M., Forawi, S. and Mansour, N. (2020) Incorporating Entrepreneurial Practices into STEM Education: Development of Interdisciplinary E-STEM Model in High School in the United Arab Emirates. *Thinking Skills and Creativity*, **37**, Article 100697. <https://doi.org/10.1016/j.tsc.2020.100697>
- [11] Farrell, R. and Sugrue, C. (2021) Sustainable Teaching in an Uncertain World: Pedagogical Continuities, Unprecedented Challenges. In: Hernandez-Serrano, M.J., Ed., *Teacher Education in the 21st Century: Emerging Skills for a Changing World*, IntechOpen, 101-117.
- [12] Rinke, C.R., Gladstone-Brown, W., Kinlaw, C.R. and Cappiello, J. (2016) Characterizing STEM Teacher Education: Affordances and Constraints of Explicit STEM Preparation for Elementary Teachers. *School Science and Mathematics*, **116**, 300-309.  
<https://doi.org/10.1111/ssm.12185>
- [13] Weinberg, A.E. and Sample McMeeking, L.B. (2017) Toward Meaningful Interdisciplinary Education: High School Teachers' Views of Mathematics and Science Integration. *School Science and Mathematics*, **117**, 204-213.  
<https://doi.org/10.1111/ssm.12224>
- [14] Sahin, A. and Top, N. (2015) STEM Students on the Stage (SOS): Promoting Student Voice and Choice in STEM Education through an Interdisciplinary, Standards-Focused, Project-Based Learning Approach. *Journal of STEM Education: Innovations and Research*, **16**, 24-33.
- [15] Eltanahy, M., Forawi, S. and Mansour, N. (2020) STEM Leaders and Teachers Views of Integrating Entrepreneurial Practices into STEM Education in High School in the United Arab Emirates. *Entrepreneurship Education*, **3**, 133-149.  
<https://doi.org/10.1007/s41959-020-00027-3>
- [16] Margot, K.C. and Kettler, T. (2019) Teachers' Perception of STEM Integration and Education: A Systematic Literature Review. *International Journal of STEM Education*, **6**, Article No. 2. <https://doi.org/10.1186/s40594-018-0151-2>
- [17] Madden, L., Beyers, J.E.R. and Stanton, N. (2020) Future Elementary Teachers' Perspectives on the Importance of STEM. In: Akerson, V.L. and Buck, G.A., Eds., *Critical Questions in STEM Education*, Springer, 159-170.
- [18] Radloff, J. and Guzey, S. (2016) Investigating Preservice STEM Teacher Conceptions of STEM Education. *Journal of Science Education and Technology*, **25**, 759-774.  
<https://doi.org/10.1007/s10956-016-9633-5>
- [19] Holmlund, T.D., Lesseig, K. and Slavit, D. (2018) Making Sense of "STEM Education" in K-12 Contexts. *International Journal of STEM Education*, **5**, Article No. 32.  
<https://doi.org/10.1186/s40594-018-0127-2>
- [20] Thibaut, L., Knipprath, H., Dehaene, W. and Depaepe, F. (2018) The Influence of Teachers' Attitudes and School Context on Instructional Practices in Integrated STEM Education. *Teaching and Teacher Education*, **71**, 190-205.  
<https://doi.org/10.1016/j.tate.2017.12.014>
- [21] Berisha, F. and Vula, E. (2024) Introduction of Integrated STEM Education to Pre-Service Teachers through Collaborative Action Research Practices. *International Journal of Science and Mathematics Education*, **22**, 1127-1150.  
<https://doi.org/10.1007/s10763-023-10417-3>

- [22] Akiri, E., Tor, H.M. and Dori, Y.J. (2021) Teaching and Assessment Methods: STEM Teachers' Perceptions and Implementation. *Eurasia Journal of Mathematics, Science and Technology Education*, **17**, em1969. <https://doi.org/10.29333/ejmste/10882>
- [23] English, L.D. (2017) Advancing STEM Education in K-12: A Focus on Problem Solving and Creativity. In: Taber, K.S. and Akpan, B., Eds., *Science Education: New Directions in Mathematics and Science Education*, Sense Publishers, 37-52.
- [24] Czerniak, C.M. and Johnson, C.C. (2014) Interdisciplinary Science Teaching. In: Lederman, N.G. and Abell, S.K., Eds., *Handbook of Research on Science Education (Vol. 2)*, Routledge, 395-411.
- [25] Fraser, B.J. (2013) Classroom Learning Environments: Retrospect, Context and Prospect. In: Fraser, B.J., Tobin, K. and McRobbie, C.J., Eds., *Second International Handbook of Science Education*, Springer, 1191-1209.
- [26] Anderson, J. and Li, Y. (2020) Integrated Approaches to STEM Education: An International Perspective. Springer.
- [27] Bonwell, C.C. and Eison, J.A. (1991) Active Learning: Creating Excitement in the Classroom. ASHE-ERIC Higher Education Report No. 1. The George Washington University, School of Education and Human Development.
- [28] Honey, M., Pearson, G. and Schweingruber, H. (2014) STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research. National Academies Press.
- [29] Lave, J. and Wenger, E. (1991) Situated Learning: Legitimate Peripheral Participation. Cambridge University Press.
- [30] Wang, H.H., Moore, T.J., Roehrig, G.H. and Park, M.S. (2011) STEM Integration: Teacher Perceptions and Practice. *Journal of Pre-College Engineering Education Research*, **1**, Article 2.
- [31] Putnam, R.T. and Borko, H. (2000) What Do New Views of Knowledge and Thinking Have to Say about Research on Teacher Learning? *Educational Researcher*, **29**, 4-15. <https://doi.org/10.3102/0013189x029001004>
- [32] Applefield, J.M., Huber, R.L. and Moallem, M. (2000) Constructivism in Theory and Practice: Toward a Better Understanding. *The High School Journal*, **84**, 35-53.
- [33] Vygotsky, L.S. (1962) Thought and Language. MIT Press.
- [34] Wood, D., Bruner, J.S. and Ross, G. (1976) The Role of Tutoring in Problem Solving. *Journal of Child Psychology and Psychiatry*, **17**, 89-100. <https://doi.org/10.1111/j.1469-7610.1976.tb00381.x>
- [35] Roehrig, G.H., Wang, H.-H., Moore, T.J. and Park, M. (2012) Is Adding the E Enough? Investigating the Impact of K-12 Engineering Standards on the Implementation of STEM Integration. *International Journal of Science and Mathematics Education*, **10**, 1207-1225.
- [36] Wright, D.S., Balgopal, M.M., Sample McMeeking, L.B. and Weinberg, A.E. (2019) Developing Resilient K-12 STEM Teachers. *Advances in Developing Human Resources*, **21**, 16-34. <https://doi.org/10.1177/1523422318814483>
- [37] Wan, Z.H., So, W.M.W. and Zhan, Y. (2022) Developing and Validating a Scale of STEM Project-Based Learning Experience. *Research in Science Education*, **52**, 599-615. <https://doi.org/10.1007/s11165-020-09965-3>
- [38] Moore, T.J., Stohlmann, M.S., Wang, H.H., Tank, K.M. and Roehrig, G.H. (2014) Implementation and Integration of Engineering in K-12 STEM Education. In: Strobel, J.S., Purzer, S. and Cardella, M., Eds., *Engineering in Pre-College Settings: Research into Practice*, Purdue University Press, 35-60.
- [39] LaForce, M., Noble, E., King, H., Century, J., Blackwell, C., Holt, S., et al. (2016) The

- Eight Essential Elements of Inclusive STEM High Schools. *International Journal of STEM Education*, **3**, Article No. 21. <https://doi.org/10.1186/s40594-016-0054-z>
- [40] Vasquez, J.A., Sneider, C. and Comer, M. (2013) STEM Lesson Essentials, Grades 3-8: Integrating Science, Technology, Engineering, and Mathematics. Heinemann.
- [41] Thu, H.L.T., Hong, C.N.T., Huy, V.N. and Thi, B.L. (2024) A Systematic Review of Research on Gender Diversity in STEM Education. *International Journal of Learning, Teaching and Educational Research*, **23**, 217-233. <https://doi.org/10.26803/ijlter.23.4.12>
- [42] Dasgupta, N. and Stout, J.G. (2014) Girls and Women in Science, Technology, Engineering, and Mathematics: STEMing the Tide and Broadening Participation. *Policy Insights from the Behavioral and Brain Sciences*, **1**, 21-29.
- [43] Portillo-Blanco, A., Guisasola, J. and Zuza, K. (2025) Integrated STEM Education: Addressing Theoretical Ambiguities and Practical Applications. *Frontiers in Education*, **10**, Article 1568885. <https://doi.org/10.3389/educ.2025.1568885>
- [44] Harris, C.M., Graham, D., Gilbert, D., Musial, D., Member, C. and Brandt, C. (2018) Perceptions of Chemistry Teachers Regarding the Process of Implementing Project-Based Learning.
- [45] Zhang, L. and Ma, Y. (2023) A Study of the Impact of Project-Based Learning on Student Learning Effects: A Meta-Analysis Study. *Frontiers in Psychology*, **14**, Article 1202728. <https://doi.org/10.3389/fpsyg.2023.1202728>
- [46] Nurmaliah, C., Azmi, T., Safrida, K. and Artika, W. (2021) The Impact of Implementation of STEM Integrating Project-Based Learning on Students' Problem-Solving Abilities. *Journal of Physics: Conference Series*, **1882**, Article 012162. <https://doi.org/10.1088/1742-6596/1882/1/012162>
- [47] Du, W., Liu, D., Johnson, C.C., Sondergeld, T.A., Bolshakova, V.L.J. and Moore, T.J. (2019) The Impact of Integrated STEM Professional Development on Teacher Quality. *School Science and Mathematics*, **119**, 105-114. <https://doi.org/10.1111/ssm.12318>
- [48] Haviland, S. and Robbins, S. (2021) Career and Technical Education as a Conduit for Skilled Technical Careers: A Targeted Research Review and Framework for Future Research. *ETS Research Report Series*, **2021**, 1-42. <https://doi.org/10.1002/ets2.12318>
- [49] Creswell, J.W. and Creswell, J.D. (2018) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 5th Edition, Sage Publications.
- [50] Johnson, R.B. and Christensen, L.B. (2017) *Educational Research: Quantitative, Qualitative, and Mixed Approaches*. 6th Edition, Sage Publications.
- [51] Creswell, J.W. and Poth, C.N. (2018) *Qualitative Inquiry & Research Design: Choosing among Five Approaches*. 4th Edition, Sage Publications.
- [52] Creswell, J.W. (2015) *A Concise Introduction to Mixed Methods Research*. Sage Publications.
- [53] Merriam, S.B. and Tisdell, E.J. (2015) *Qualitative Research: A Guide to Design and Implementation*. 4th Edition, Jossey-Bass.
- [54] Gubrium, J.F., Holstein, J.A., Marvasti, A.B. and McKinney, K.D. (2012) *The SAGE Handbook of Interview Research: The Complexity of the Craft*. Sage Publications.
- [55] Merriam, S.B. (2009) *Qualitative Research: A Guide to Design and Implementation*. Jossey-Bass.
- [56] Braun, V. and Clarke, V. (2013) *Successful Qualitative Research: A Practical Guide for Beginners*. Sage Publications.

- [57] Silverman, D. (2013) *Doing Qualitative Research: A Practical Handbook*. 4th Edition, Sage Publications.
- [58] Brinkmann, S. and Kvale, S. (2018) *Doing Interviews*. 2nd Edition, Sage Publications. <https://doi.org/10.4135/9781529716665>
- [59] Gardner, K., Glassmeyer, D.M. and Worthy, R. (2019) Impacts of STEM Professional Development on Teachers' Knowledge, Self-Efficacy, and Practice. *Frontiers in Education*, **4**, Article 26. <https://doi.org/10.3389/educ.2019.00026>
- [60] Hyde, K.F., Ryan, C. and Woodside, A.G. (2013) Five-Phase Method for the Analysis and Interpretation of Data in Case Study Research. In: Woodside, A.G., Ed., *Case Study Research: Theory, Methods and Practice*, Emerald Group Publishing Limited, 129-158.
- [61] Bryman, A. and Bell, E. (2011) *Business Research Methods*. 3rd Edition, Oxford University Press.
- [62] Gajjar, N.B. (2013) Ethical Consideration in Research. *International Journal for Research in Education*, **2**, 8-15.
- [63] Zhang, J., Zhou, M. and Zhang, X. (2023) Interventions to Promote Teachers' Perceptions about STEM Education: A Meta-Analysis. *Education and Information Technologies*, **28**, 7355-7390. <https://doi.org/10.1007/s10639-022-11492-9>