

الجامعة
البريطانية في
دبي



The
British University
in Dubai

Investigating Educators' Perceptions of the Impact of STEM Project-Based Learning on 21st Century Skills

استكشاف تصورات المربين حول تأثير تعلم العلوم والتكنولوجيا والهندسة
والرياضيات (التعليم المبني على المشروع) على مهارات القرن الواحد
والعشرين

by

SANAA AL-TIMANI

Dissertation submitted in partial fulfilment

of the requirements for the degree of

MASTER OF EDUCATION

at

The British University in Dubai

March 2024

Declaration

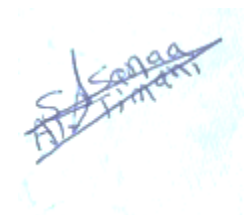
I warrant that the content of this research is the direct result of my own work and that any use made in it of published or unpublished copyright material falls within the limits permitted by international copyright conventions.

I understand that a copy of my research will be deposited in the University Library for permanent retention.

I hereby agree that the contents of this dissertation for which I am author and copyright holder may be copied and distributed by The British University in Dubai for the purposes of research, private study or education and that The British University in Dubai may recover from purchasers the costs incurred in such copying and distribution, where appropriate.

I understand that The British University in Dubai may make a digital copy available in the institutional repository.

I understand that I may apply to the University to retain the right to withhold or to restrict access to my thesis for a period which shall not normally exceed four calendar years from the congregation at which the degree is conferred, the length of the period to be specified in the application, together with the precise reasons for making that application.



Students Signature

Copyright and Information to Users

The author whose copyright is declared on the title page of the work has granted to the British University in Dubai the right to lend his/her research work to users of its library and as an open source and to make partial or single copies for educational and research use.

The author has also granted permission to the University to keep or make a digital copy for similar use and for the purpose of preservation of the work digitally.

Multiple copying of this work for scholarly purposes may be granted by either the author, the Registrar or the Dean only.

Copying for financial gain shall only be allowed with the author's express permission.

Any use of this work in whole or in part shall respect the moral rights of the author to be acknowledged and to reflect in good faith and without detriment the meaning of the content, and the original authorship.

Abstract

This study investigates educators' perspectives on STEM Project-Based Learning (PBL) implementation and its effectiveness in fostering 21st century skills in private American schools in Ajman, UAE. It also explores how demographic factors among educators influence their views on STEM PBL's efficacy in promoting these skills. Given the limited research in the UAE on this topic, the study aims to fill this gap. Using a mixed-method approach, 116 science, math, and ICT teachers from three Ajman schools (elementary, middle, and high school) participated. Quantitative data were gathered through an 18-item questionnaire covering five dimensions, while qualitative data were collected through interviews with four teacher leaders and open-ended questions within the questionnaire. The findings indicate that the 18 items play a significant role in the implementation and practices of STEM PBL to develop 21st century skills. Teachers identified several challenges, such as managing extensive curriculum content, time constraints, limited resources, and difficulties in interdisciplinary collaboration. Demographic factors like gender, age, academic qualification, or teaching experience did not significantly influence perceptions. However, the grade levels taught had a notable impact, with high school teachers showing greater proficiency in STEM PBL. The study suggests the need for further research with broader samples and larger teacher cohorts. It concludes that while STEM PBL is beneficial, ongoing professional development is crucial to help educators overcome challenges and effectively foster 21st century skills in students.

Keywords: STEM Project-Based Learning (PBL), 21st century skills

خلاصة

تستقصي هذه الدراسة وجهات نظر المعلمين حول تنفيذ التعلم القائم على المشاريع في مجالات العلوم والتكنولوجيا والهندسة والرياضيات وفعاليتها في تعزيز مهارات القرن الواحد والعشرين في المدارس الأمريكية الخاصة في عجمان، الإمارات العربية المتحدة. كما تستكشف كيف تؤثر العوامل الديموغرافية بين المعلمين على آرائهم حول فعالية التعلم القائم على المشاريع في مجالات العلوم والتكنولوجيا والهندسة والرياضيات في تعزيز هذه المهارات. نظراً لقلة الأبحاث في الإمارات العربية المتحدة حول هذا الموضوع، تهدف الدراسة إلى سد هذه الفجوة. باستخدام منهج متعدد الأساليب، شارك 116 معلماً في العلوم والرياضيات وتكنولوجيا المعلومات والاتصالات من ثلاث مدارس في عجمان (الابتدائية والمتوسطة والثانوية). تم جمع البيانات الكمية من خلال استبيان مكون من 18 عنصراً يغطي خمسة أبعاد، بينما تم جمع البيانات النوعية من خلال مقابلات مع أربعة قادة تربويين وأسئلة مفتوحة داخل الاستبيان. تشير النتائج إلى أن العناصر الثمانية عشر تلعب دوراً هاماً في تنفيذ وممارسات التعلم القائم على المشاريع لتطوير مهارات القرن الواحد والعشرين. حدد المعلمون عدة تحديات، مثل إدارة محتوى المناهج الشامل، قيود الوقت، الموارد المحدودة، والصعوبات في التعاون بين التخصصات. لم تؤثر العوامل الديموغرافية مثل الجنس، العمر، المؤهل الأكاديمي، أو الخبرة التعليمية بشكل كبير على التصورات. ومع ذلك، كان لمستويات الصف التي يتم تدريسها تأثير كبير، حيث أظهر معلمو المدارس الثانوية كفاءة أكبر في التعلم القائم على المشاريع. تقترح الدراسة الحاجة إلى مزيد من الأبحاث مع عينات أوسع ومجموعات أكبر من المعلمين. وتخلص إلى أنه على الرغم من فوائد التعلم القائم على المشاريع، فإن التطوير المهني المستمر ضروري لمساعدة المعلمين على التغلب على التحديات وتعزيز مهارات القرن الواحد والعشرين لدى الطلاب بشكل فعال.

الكلمات المفتاحية: تعلم المشروع القائم على التخصصات الأربعة - مهارات القرن الواحد والعشرين

Dedication

To my dad, a symbol of resilience and unconditional love. Despite physical distance, your lasting influence is evident, and my affection for you remains steadfast. To my mom, a constant wellspring of motivation. You embodied a woman of faith, highlighting the significance of prioritizing faith, family, and career. To my brother and sisters, you are the pillars of my foundation, each bringing a unique strength and warmth to my life. To my friends, the cherished companions who have walked alongside me through both joys and challenges. To my son Kinan, you are the heartbeat that rhythmically guides my life. Your understanding and support in my pursuit of lifelong learning are cherished more than words can express. Finally, to my husband, my unwavering support throughout every aspect of my journey. Your steadfast encouragement has been crucial. I couldn't have achieved this without you.

Acknowledgements

I begin by expressing my deepest gratitude to Almighty Allah for the blessings that have enabled me to successfully complete my research. A profound acknowledgment is extended to my research supervisor, Prof. Sufian A. Forawi, whose instrumental role not only provided me with the opportunity to conduct this study but also encompassed unwavering support and insightful guidance throughout this transformative journey. Prof. Forawi's visionary leadership, encouragement, and unwavering support were paramount in shaping the trajectory of my research and fostering the determination to achieve this milestone. Additionally, I want to acknowledge the invaluable support from all my family and friends who stood by me during this endeavor.

Table of Contents

Chapter 1: Introduction.....	1
1.1 Introduction.....	1
1.2 Background of the Study	4
1.3 Problem Statement	7
1.4 Purpose of the Study	10
1.5 Research Questions.....	10
1.6 Significance of the Study	10
1.7 The Structure of the Study	11
Chapter 2: Literature Review	12
2.1 Theoretical Framework.....	12
2.1.1 Integrative Theory	13
2.1.2 Social-Cognitive Constructivist Theory	15
2.1.3 Constructivism Theory	18
2.2 Literature Review	19
2.2.1 Perspective in the Context of STEM Education	20
2.2.2 Project Based Learning.....	23
2.2.3 Impact of STEM-Project Based Learning Activities on the Enhancement of 21 st Century Skills.....	26
2.2.4 Teachers' Perspectives on Implementing STEM Project-Based Learning on the Enhancement of 21 st Century Skills	28
Chapter 3: Methodology	34
3.1 Research Design	34

3.2 The Research Population and Sample	36
3.3 Instruments of the study.....	37
3.4 Reliability of the Questionnaire	39
3.5 Validity of the Questionnaire.....	42
3.6 Research Procedure.....	42
3.7 Data Analysis.....	43
3.8 Ethical Considerations	44
Chapter 4: Data Analysis and Results.....	46
4.1 The Study Results	46
4.2 Demographic Information of the Questionnaire	46
4.3 Results Related to Question 1	48
4.4 Results Related to Question 2	60
4.5 Results Related to Question 3(The interview)	64
4.6 Results of Open-Ended Questions	68
Chapter 5: Discussion, Conclusion, Recommendations, and Limitations	74
5.1 Discussion.....	74
5.2 Conclusion	81
5.3 Recommendations.....	82
5.4 Limitations	83
References	85
Appendices	94

List of Tables

Table 1: Cronbach's Alpha of the Questionnaire	40
Table 2: Pearson Correlation.....	41
Table 3: Distribution and Percentage of Demographic Categorical Variables	47
Table 4: Frequency, Mean, Standard Deviation, and Percentage of the Perceptions of Educators on the Implementation of STEM PBL on 21 st Century Skills.....	48
Table 5: Frequency, Mean ,Standard Deviation, and Percentage of the Teachers' Perceptions About Instructional Integration Items on the Implementation of STEM PBL on 21 st Century Skills.....	51
Table 6: Frequency, Mean, Standard Deviation, and Percentage of the Teachers' Perceptions About Engagement Items on the Implementation of STEM PBL on 21 st Century Skills.....	52
Table 7: Frequency, Mean, Standard Deviation, and percentage of the Teachers' Perceptions About Professional Development Items on the Implementation of STEM PBL on 21 st Century Skills.....	53
Table 8: Frequency, Mean, Standard Deviation, and Percentage of the Teachers' Perceptions About Challenges Items on the Implementation of STEM PBL on 21 st Century Skills.....	54
Table 9: Mean and Standard Deviation of the Scale Variables.....	55
Table 10: Linear Regression Analysis of Independent Variables on STEM Project-Based	59
Table 11: Mean, Standard Deviation, T-Student, F-Fisher, and P-Value of the Demographic Variables.....	64
Table 12: Educator's Responses to Open-Ended Question (1)	68
Table 13: Educator's Responses to Open-Ended Question (2)	70

Table 14: Educator's Responses to Open-Ended Question (3)	71
---	----

Table 15: Educator's Responses to Open-Ended Question (4)	72
---	----

List of Figures

Figure 1: Theoretical Framework of the Study	13
--	----

Chapter 1: Introduction

1.1 Introduction

Globalization is the worldwide interchange of economic, social, and cultural elements (Baran et al., 2021). It serves not only commercial interests but plays a significant role in the realm of education. In the present era, rapid global advancements driven by new technologies give rise to emerging challenges. These advancements set high expectations and present challenging contests and obstacles for the future. The UAE, a major oil producer, has experienced a decline in oil prices over the last three decades as the global oil market became saturated. Currently, the world is shifting its focus to technological innovations and advancements, which are expected to play a crucial role in shaping the future and driving economic growth (Murshidi, 2019). Consequently, the education sector must exert greater efforts to align with the UAE's new economic vision, where the emphasis on technology and innovation becomes foundational, marking a shift from an oil-based to a knowledge-based economy (Eltanahy & Forawi, 2020). To enhance competitiveness with other industrial nations, it is crucial to foster more graduate students in STEM fields (Jarrar, 2020).

The UAE's Vice-President, Prime Minister, and ruler of Dubai, Shaikh Mohammad Bin Rashid Al Maktoum, has stressed the value of developing a cutting-edge scientific environment in UAE. He stressed that investing in scientific progress is essential for shaping the future and turning human creativity into tangible accomplishments (UAE Government, 2018). To achieve this goal, there is a requirement for revamping science education. The transformation of the educational system requires preparing students for evolving job markets and emerging challenges associated with new issues and the continuous advancements in technology, which are changing and expanding on a daily basis.

In the contemporary world, there is a demand for individuals possessing 21st century skills, including critical thinking, communication, collaboration, problem-solving, good use of technology ,and creativity(Tunc & Bagceci, 2021). The STEM approach is one of the educational methods fostering the development of these skills(Tunc & Bagceci, 2021). Consequently, as a result of the increasing requirements for technological and scientific expertise in contemporary society, the demand has shifted to a necessity for well-educated individuals equipped with skills in the STEM workforce, encompassing science, technology, engineering, and mathematics(Baran et al., 2021).

Therefore, contemporary nations are increasingly prioritizing investment in the STEM workforce as a part of their national objectives(Baran et al., 2021). This rise is attributed to the alignment between the demands of employers or manufacturers in the 21st century and the need for STEM skills(Baran et al., 2021). Therefore, there is a growing need to move away from conventional teaching methods and embrace an integrated approach like interdisciplinary STEM education(Capraro, R. M., Capraro, M. M., Morgan, 2013). Accordingly, education systems in countries are undergoing a transformation to produce individuals with 21st century skills(Baran et al., 2021). This transition not only enhances critical thinking skills in learners but also equips them to become proactive and influential contributors to their communities.

STEM is a globally recognized initiative that contributes to enhancing the academic achievements of highly qualified graduates. The educational reforms such as the Next Generation Science Standards (NGSS) and the Common Core State Standards for Mathematics (CCSSM) play a crucial role in advancing STEM education by shaping the perception of current STEM methodologies(Jarrar, 2020).Significantly, STEM education, in particular, holds

substantial potential for enhancing students' learning outcomes by integrating classroom responsibilities with real-life applications(Eltanahy & Forawi, 2019).

Nevertheless, there are various methods of incorporating STEM into education, leading to a lack of agreement on the implementation of effective STEM instruction(Wieselmann, Sager, 2022). Since Project-based Learning(PBL) involves the creation of projects and practice-oriented learning, aligning with the "engineering" skills in STEM education, these two approaches STEM and Project-Bases Learning (PBL) are inherently similar(Baran et al., 2021). STEM education involves a teaching and learning approach that encompasses skills in science, technology, engineering, and mathematics(Baran et al., 2021). Project-based learning (PBL) is an active learning approach that cultivates skills in individuals, including project creation, systematic presentation of information or data, effective communication, and collaborative teamwork(Baran et al., 2021).Consequently, project-based learning is recognized as one of the most suitable methods for fostering the development of STEM skills. STEM Project-Based Learning (PBL) involves students in real-world tasks that lead to specific learning outcomes, aligning with the current standards-based educational model(Capraro, R. M., Capraro, M. M., Morgan, 2013).

The integration of STEM with project-based learning (PBL) has shown effectiveness as it endeavors to align with the K-12 science education standards and the framework of the Next Generation Science Standards (NGSS) (Jarrar, 2020).Utilizing project-based learning (PBL) in conjunction with STEM serves as a method to enhance student engagement and learning, equipping them for success in the 21st century(Wieselmann, Sager, 2022).

Teachers are enthusiastic about fostering this form of learning in the classroom. The role of teachers is crucial in seamlessly integrating innovations like STEM project-based learning into the education system and addressing encountered challenges. This study helps to investigate teachers' perceptions regarding the effectiveness of STEM project-based learning in enhancing 21st century skills. Teachers play a crucial role in promoting student retention and success. In light of evolving societal norms, educators must employ diverse strategies to connect students with technology, including the use of iPhones and social media(Haddad, 2022). Teachers have an opportunity to engage with students through Project-Based Learning (PBL). Delivering meaningful, hands-on projects through the STEM PBL approach emerges as a valuable strategy to prepare students for the complexities and opportunities of the present-day world.

1.2 Background of the Study

With the goal of preparing high school graduates for global competitiveness, STEM education—originally known as SMET (Science, Mathematics, Engineering, and Technology)—emerged in the US in the early 1990s and was introduced by the National Science Foundation (Chaya, 2023). Consequently, STEM education aims to develop graduates who are proficient in science, technology, engineering, and mathematics, equipped with the essential skills to excel in a future workforce that is heavily reliant on technology(Hamad et al., 2022). STEM is characterized by its interdisciplinary approach, emphasizing student-centered learning and the integration of science, technology, mathematics, and engineering to address and tackle real-life challenges(Capraro, R. M., Capraro, M. M., Morgan, 2013).

Currently, the incorporation of STEM (Science, Technology, Engineering, and Mathematics) into education is a widely adopted teaching method. It plays a crucial role in offering students a comprehensive education in science and various other subjects(Aziz, 2015). To fulfill this aim, the UAE's education system is undergoing a shift towards STEM education as outlined in its reform plans. The objective is to cultivate an innovative education system that promotes knowledge and prepares students for global competitiveness, aligning with international market demands(Hamad et al., 2022).In addition to various innovation conferences and festivals, there is a focus on professional development initiatives. These efforts aim to enhance the skills and capabilities of educators, ensuring they are well-equipped to effectively integrate STEM elements into their teaching methodologies and contribute to the overall success of the educational reforms(Bush, 2019).

Moreover, STEM furnishes students with a strong grounding in science, technology, engineering, and mathematics(Tunc & Bagceci, 2021). The educational approaches associated with STEM are acknowledged as one of the swiftly progressing domains in the field of education, encompassing both developed and developing nations(Tunc & Bagceci, 2021).Additionally, STEM education fuels student success and interest in STEM fields, while nurturing crucial 21st century skills like problem-solving, critical thinking, creativity, and experimentation(Baran et al., 2021).

Over the past thirty years, significant educational reforms have been implemented in Arab countries, but their impact on the quality of science education remains largely unexplored(Madani, 2021). While curricular changes in GCC countries have led to improvements in math and science performance, students' scores in international assessments like TIMSS and PISA still fall below the global average, influenced by various factors(Madani,

2021).Gulf Cooperation Council (GCC) nations are shifting their focus toward the widespread adoption of STEM education, aiming to foster a new generation of scientists and innovators(Madani, 2021).

Project-based learning (PBL), which originated over half a century ago, engages students in solving real-life problems, providing them with opportunities to showcase their knowledge and learning(Haddad, 2022). As an innovative approach, project-based learning is a constructive method that fosters individuals' skills in producing projects, presenting information systematically, establishing communication, and collaborating in a team. This method not only encourages learning through research but also enables individuals to generate solutions for real-life challenges(Baran et al., 2021).

STEM-PBL is receiving significant attention from many schools in the UAE and various countries as they seek a highly effective and quality education(Fouad, 2018).The integration of PBL in STEM education aligns with the evolving needs of the modern workforce, which requires individuals to possess not only content knowledge but also the ability to apply that knowledge in practical, real-world contexts. Research conducted in the United Arab Emirates indicates that children who received instruction using the STEM-PBL approach demonstrated greater overall progress, particularly in 21st century skills such as creativity, critical thinking, communication, and information technology competency (Jarrar, 2020). Transitioning from traditional teaching methods to STEM Project-Based Learning (PBL) aids in cultivating an innovative generation with the ability to effectively tackle challenges(Wan Husin et. al, 2021). The STEM Project-Based Learning (PBL) approach significantly impacts students' learning and the educational process, resulting in the production of highly skilled engineers and

educators capable of competing on a global scale and meeting national and international workforce demands(Capraro, 2017).

Teachers might experience a sense of being overwhelmed when managing STEM-PBL classrooms as these projects demand planning and management skills that may be unfamiliar to educators(Haddad, 2022). Examining educators' views on PBL offers crucial insights into the factors influencing its success, aiding policymakers, curriculum developers, and teachers in designing effective STEM-PBL experiences for developing 21st century skills. This research aligns with my professional goals and represents a personal and scholarly pursuit. Focusing on a specific project within the research allows us to deepen our understanding of STEM-PBL and its pivotal role in enriching students' overall learning experience.

1.3 Problem Statement

While STEM education research and policies have received global attention, studies on STEM education in Asia remain relatively underrepresented, comprising only 8.5% of international STEM education publications from 2013 to 2017(Cheng, 2022). The demand for individuals with technological and scientific skills has surpassed the need for physical strength in today's society. This shift has led to a mandatory change in the requirements of the current era, where well-educated individuals with STEM expertise are essential(Baran et al., 2021).Jobs in this era necessitate 21st century skills such as critical thinking, problem-solving, teamwork, technological proficiency, interdisciplinary collaboration, effective communication, and creativity. Consequently, countries rely on individuals with STEM skills to drive economic growth and effectively participate in the global economy(Baran et al., 2021). As a result, investment in the STEM workforce has become a priority for many nations. Employers and

manufacturers in the 21st century align their demands with STEM skills, prompting the need for educational systems to adapt and cultivate individuals equipped with 21st century competencies(Atabey &Topcu, 2020).

There is still a lack of clarity and consistency in the perception, implementation, and criteria for success in STEM education among many countries that have adopted STEM initiatives. Despite the promising prospects offered by STEM fields, there has been a decline in student interest in pursuing STEM careers in various countries, including the United States and Turkey(Atabey &Topcu, 2020). For instance, the percentage of students graduating from undergraduate STEM programs in the United States dropped from 32% in 1995 to 27% in 2004. Similarly, in Turkey, undergraduate enrollment in STEM fields decreased from 85.63% in 2000 to 27.88% in 2010, with a modest increase to 38.23% in 2014(Atabey &Topcu, 2020). Boosting enrollment in STEM fields is crucial for ensuring economic growth. To achieve this, it is essential to identify students' current interest in STEM careers and understand the factors influencing this interest. Therefore, nurturing and enhancing 21st century skills have been identified as a means to increase students' interest and inclination towards STEM careers(Atabey &Topcu, 2020).Moreover, according to Park et al. (2016), in South Korea, STEM education has been implemented for a considerable period; however, there is limited knowledge about the actual implementation of STEM in Korean schools. Similarly, the situation in the United Arab Emirates (UAE) is similar to other countries that have adopted STEM education, as there remains uncertainty surrounding the perception and implementation of STEM. There is no standardized approach to implementing STEM, and each school in the UAE may adopt its own methods. Consequently, a variety of techniques for implementing STEM can be found in American schools in the UAE. However, it is important to note that not

all of these techniques may be successful in achieving the targets set by the Ministry of Education (MOE).

Collaborative efforts between institutions such as the Knowledge and Human Development Authority (KHDA) and the Ministry of Education (M.O.E.) are geared towards improving 21st century skills and nurturing students' interest in STEM fields, aligning with the U.A.E. Vision 2030(Jarrar, 2020).To meet these needs and participate in the global economy, countries rely on individuals equipped with STEM skills(Baran et al., 2021). Project-based Learning (PBL) is one of the constructive approaches integrated into STEM education, closely associated with engineering skills within the STEM framework(Baran et al., 2021).PBL is viewed as a favorable approach for fostering STEM skills(Baran et al., 2021) and STEM project-based learning signifies an instructional method that incorporates STEM education into the curriculum design. On the other hand, flexibility in education, similar to STEM-Project-Based Learning, involves a shift from teacher-centered to student-centered learning. This transition empowers students to take on a more active role in their education, fostering increased engagement. However, the non-traditional nature of STEM-PBL poses challenges for teachers, as their perceptions may differ. While teachers may have theoretical knowledge about STEM-PBL, they might feel unprepared in practice to effectively facilitate this instructional approach in the classroom that will improve the 21st century skills.

Limited research in the United Arab Emirates examines how STEM project-based learning enhances 21st century skills, particularly from the perspective of teachers. The absence of extensive research in this domain serves as a motivation for conducting this study. Furthermore, educators in the UAE face challenges when implementing STEM Project-Based

Learning, mainly due to their limited prior exposure or understanding of this pedagogical approach.

1.4 Purpose of the Study

The study aims to investigate educators' perceptions and practices of the STEM project-based learning implementation in advancing 21st century skills, in private American schools in Ajman, UAE. Additionally, to find demographic differences among educators in Ajman schools that impact their viewpoints regarding the efficacy of STEM Project-Based Learning in promoting 21st century skills.

1.5 Research Questions

Considering the study's intent, the following questions were formulated:

1. What are educators' perceptions regarding the implementation of STEM project-based learning in enhancing 21st century skills in private American schools in Ajman, the United Arab Emirates?
2. How do the demographic differences among educators in Ajman schools impact their perspectives on the effectiveness of STEM project-based learning in fostering 21st century skills?
3. What practices do educators employ when implementing STEM Project-Based Learning?

1.6 Significance of the Study

Understanding teachers' perceptions on the effectiveness of STEM project-based learning is crucial as it has the potential to significantly enhance students' achievements and foster

greater interest in pursuing STEM careers(Jarrar, 2020). The insights gained from this study can guide learners with practical techniques, enabling them to formulate better solutions and strengthen 21st century skills such as critical thinking, creativity, collaboration, and problem-solving(Jarrar, 2020). Additionally, successful integration of STEM Project-Based learning education relies on the leadership and guidance provided by educators. The study aspired to offer valuable insights for educational leaders and educators.

1.7 The Structure of the Study

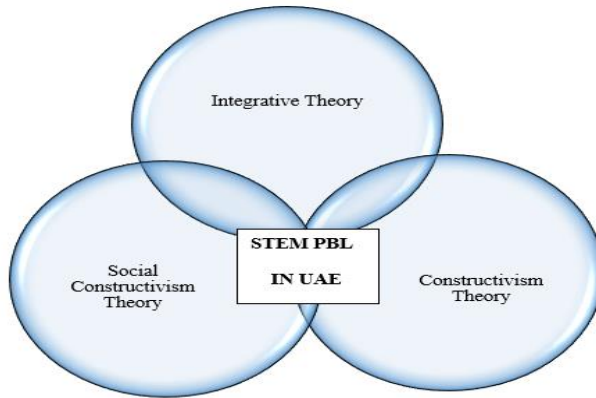
The research is structured into five main chapters. The first chapter introduces the topic's significance, provides general information about its variables, and offers a historical context. It outlines the research topic, objectives, research questions, and concludes with a summary of the study's significance. In the second chapter, the theoretical framework and a review of relevant literature are presented, including insights from previous studies on the same topic. The third chapter explains the research methodology, covering the research design, study population and sample, instrumentation, research protocols, ethical considerations, and how relevant data will be presented in tables or charts. It also discusses reporting questionnaire findings. Moving on to the fourth chapter, it presents the study's key findings, summarizes data analysis, and engages in a discussion of the findings. Finally, the fifth chapter concludes the study and offers insights, recommendations and acknowledges the limitations of the study.

Chapter 2: Literature Review

Chapter two extensively verifies the literature to affirm the impact of STEM-project based learning on the enhancement of 21st century skills. The initial section delves into the theoretical framework of the research, encompassing Integrative Theory, Social-Cognitive Constructivist Theory, and Constructivism Theory. The subsequent part focuses on an extensive review of pertinent literature, covering themes such as the scientific perspective on STEM in the UAE, project-based learning, the impact of STEM-project based learning activities on the enhancement of 21st century skills, and the teachers' perspectives on implementing STEM-project based learning.

2.1 Theoretical Framework

The theoretical framework section provides an overview and discussion of key concepts and models shaping current learning theories. It includes Integrative Theory as proposed by Drake and Burns (2004), Social Constructivism Theory by Vygotsky (1978), and Constructivism Theory by John Dewey (late 19th and early 20th centuries). Therefore, the diagram in Figure 1 depicts how the theories are interconnected to form the theoretical framework used to investigate and analyze the statistics throughout the study.

Figure 1*Theoretical Framework of the Study***2.1.1 Integrative Theory**

Integrative Theory refers to an approach that combines and connects various elements, concepts, or disciplines into a unified framework or understanding. In education, Integrative Theory could involve combining insights and methodologies from different educational approaches or subjects to create a holistic and interconnected perspective.

The three approaches—interdisciplinary, multidisciplinary, and transdisciplinary—offer various ways to achieve integration. In the context of STEM education, the interdisciplinary approach stands out as an effective and hands-on method for fostering awareness and learning across subject areas. The interdisciplinary approach, unlike subject-focused multidisciplinary integration, seamlessly merges knowledge, methodologies, and perspectives drawing from multiple subjects, converging around a particular theme (Jarrar, 2020). By integrating knowledge from various disciplines relevant to a specific problem, as emphasized in interdisciplinary theory (Eltanahy & Forawi, 2020), STEM PBL not only fosters a comprehensive understanding but also aligns with the goal of enhancing 21st century skills through a multidimensional and interconnected educational approach. Within the context of

impact on 21st century skills, the interdisciplinary approach within STEM Project-Based Learning (PBL) unfolds as a catalyst for transformative learning experiences. By seamlessly integrating knowledge from diverse disciplines, STEM PBL creates a rich educational environment where students actively apply theoretical concepts to real-world challenges. This dynamic engagement not only deepens their understanding but also nurtures critical thinking, problem-solving, and collaboration skills essential components of 21st century competency. The interdisciplinary nature of STEM PBL exposes students to multifaceted perspectives, fostering adaptability and creativity in their approach to problem-solving. Thus, the impact of STEM PBL on 21st century skills is not merely theoretical; it is an immersive and interconnected educational journey that equips students with the multifaceted abilities required for success in the contemporary landscape.

The development of a multidisciplinary curriculum offers various approaches. Researchers have suggested organizing teaching around a central question, departing from fragmented perspectives (Jarrar 2020). In classrooms, teachers frequently employ multidisciplinary integration to foster teamwork. Educational reformers and educators advocate for integrating support and insights from multiple disciplines, asserting that a multidisciplinary approach enhances students' understanding of a topic or problem-solving abilities (Jarrar 2020). Nevertheless, this approach involves integrating curriculum and teaching from multiple subjects while maintaining distinct disciplinary focuses. In STEM education, it could mean combining elements from science, technology, engineering, and mathematics without fully integrating them. Smyrnova-Trybulska et al. (2016) emphasize the significance of equipping learners, especially at the foundational levels, with STEM-related

competencies. They suggest utilizing kits for constructing and coding robotics as an inventive method for interdisciplinary learning among youngsters and adolescents.

Transdisciplinary integration involves coordinating curricula and teaching through learner-centered questioning, utilizing real-life settings to enhance comprehension of concepts and skills (Jarrar, 2020). In contrast to interdisciplinary and multidisciplinary integration, transdisciplinary emphasizes an exploration of education that goes beyond classification, connecting cohesive concerns and subjects throughout the inquiry's content and context (Jarrar, 2020). Moreover, this approach highlights the importance of understanding how topics are interconnected, distinguishing it from other approaches. Furthermore, Transdisciplinary integration encompasses various methods such as developing knowledge, consciousness, and expertise relevant to the 21st century, as well as incorporating project-based learning. In STEM education, it may involve not only integrating traditional STEM subjects but also incorporating insights from other fields to solve real-world problems.

2.1.2 Social-Cognitive Constructivist Theory

Lev Vygotsky, a leading figure in social-cognitive constructivist theory, posited that learning is fundamentally a social interaction process. His goal was to elucidate how dialogue shapes cognition and to consider cognitive functions as outcomes of social interaction (Topçiu, 2015). Within the realm of social constructivist theory, ideas evolve through conversations and discussions (Admawati et al., 2018). In Vygotsky's model, children first gain knowledge through interactions with others, later integrating and modifying this knowledge to align with their individual values (Topçiu, 2015). Despite Vygotsky's argument that learning through social interactions precedes development, implementing the Zone of Proximal Development (ZPD) in

school practice can be challenging (Haddad 2022). It highlights the distinction between what an individual can learn independently and what they can learn with the support of a more knowledgeable person (Admawati et al., 2018). However, teachers need to intervene appropriately within the ZPD as necessary. By operating within the Zone of Proximal Development (ZPD), the teacher can support various internal developmental processes, ultimately guiding the learner toward independent accomplishment by scaffolding. Scaffolding is a supportive method where an instructor provides assistance, be it through discussion, supplying materials, or task design, to aid individuals in acquiring knowledge and developing understanding (Admawati et al., 2018). While a skilled teacher who recognizes when a child is within the zone of proximal development provides challenges to the student through scaffolding, they gradually withdraw assistance until the child is capable of independently completing the task (Haddad, 2022). In the role of scaffolders, teachers can act as supporters, prompters, critical listeners, feedback providers, simplifiers, motivators, or highlighters (Admawati et al., 2018). Therefore, through teacher guidance and scaffolding, Vygotsky's theory emphasizes the importance of a teacher's role in guiding students within their ZPD through scaffolding. This concept is highly relevant as it underscores how teachers, by providing appropriate support and challenges, can facilitate students' development of essential skills within the STEM PBL context.

The mention of the ZPD and scaffolding highlights the individualized approach teachers should adopt based on students' unique learning abilities. Moreover, social constructivist teachers are dedicated to aiding students in discovering their passions, facilitating opportunities for social interaction, guiding them to identify their interests, assisting in the creation of individual learning agendas, enabling self-expression through diverse media, and fostering the

understanding that students actively contribute to the construction of knowledge, empowering them to comprehend concepts autonomously (Admawati et al., 2018).

In the context of STEM Project-Based Learning (PBL), where students actively engage in collaborative and hands-on projects, the principles highlighted by Vygotsky and active learning become integral. The interactive nature of STEM PBL aligns with Vygotsky's assertion that comprehension is enhanced through interactive learning experiences (Jarrar 2020). Similarly, the concept of gradually withdrawing support until students can independently perform tasks mirrors the principles of active learning within the STEM PBL framework. This draws a parallel to the dynamic and scaffolded nature of STEM PBL, emphasizing how students, through active participation and guided support, can develop and apply 21st century skills autonomously.

Furthermore, project-based learning has roots in the sociocultural theory, particularly Lev Vygotsky's perspective (Haddad, 2022). Project-based learning involves the application of social knowledge as students collaborate to address challenges. Aligning with Vygotsky's theory, project-based learning operates within the zone where students can almost complete a task independently, with guidance. This approach utilizes Vygotsky's principles by prompting students to apply critical thinking skills, with the teacher acting as a guide, fostering a connection between them (Haddad, 2022). Nevertheless, STEM-project based learning education, rooted in social constructivist theory, is recognized for its emphasis on addressing real-life problems faced by students, particularly socio-scientific issues (Baran et al., 2021). Hence, this teaching approach acknowledges the diverse potentials of students in the classroom, recognizing that each individual possesses unique learning abilities and styles (Jarrar, 2020). The integration of sociocultural and social constructivist theories in

project-based learning, as highlighted by Vygotsky's perspective, emphasizes addressing real-life challenges collaboratively, recognizing and leveraging the diverse potentials of students in the STEM education context.

2.1.3 Constructivism Theory

Dewey advocated for a pragmatic and learner-centered approach to education, emphasizing the importance of addressing the unique needs and interests of each individual. According to Dewey, education should revolve around the concept of "learning by doing," with a strong emphasis on active participation and independent learning. He proposed that the curriculum should be made to promote critical thinking, problem-solving, and creativity. Constructionism theory emphasizes engaging learners in hands-on design activities, where they actively participate in creating, producing, or processing new products(Jarrar, 2020).

Papert (1991) introduced the concept of constructionist learning theory, which proposes that learners actively construct knowledge through engagement in the creation or design of products. He extended the concept beyond traditional "learning by doing," making it more viable for new models of "learning by work." Within this framework, the process of artifact design prompts students to actively employ and generate knowledge, thereby fostering the development of new ideas through the utilization of available digital tools(Papert, S., Harel, 1991). Furthermore, the constructionist-learning culture underscores the active participation of community members, serving as instructors or tutors to support learners in the learning process(Jarrar, 2020). This approach incorporates key learning concepts derived from both constructionist and constructivist theories, emphasizing elements such as awareness,

collaboration, problem-solving, exploration, and the integration of design and technology(Jarrar, 2020).

In addition, constructivist theory supports active learner engagement and student-centered instruction(Fouad, 2018). STEM PBL education is grounded in constructivism, forming the foundation of the current study. Dewey's influence extended to William Heard Kilpatrick, his student, who furthered Dewey's ideas. Kilpatrick developed a curriculum centered around a key theme. He advocated for teachers to offer guidance rather than commanding instruction, allowing children to shape their learning based on their interests(Haddad, 2022). Furthermore, Kilpatrick established the project method in early childhood education, aligning with the principles of progressive education. This approach involved structuring the curriculum and classroom activities around a central theme. STEM-Project-based learning draws inspiration from this theory, engaging students in collaborative projects centered around significant themes.

The mix and integration of these three theories into the curriculum, along with STEM project-based learning, are said to naturally enhance the development of students' 21st century skills.

2.2 Literature Review

This section presents an in-depth exploration of the literature relevant to the study. It encompasses key synthesized themes in the literature, addressing topics such as the Perspective in the context of STEM education, Project-Based Learning, the Influence of STEM-Project Based Learning Activities on 21st Century Skills Enhancement in UAE, and Teachers' Perspectives on Implementing STEM Project-Based Learning on the Enhancement of 21st

Century Skills .Articles from scholarly journals, which have undergone a rigorous peer review process, were collected to gather literature for the study.

2.2.1 Perspective in the Context of STEM Education

STEM education, spanning science, technology, engineering, and mathematics, is a holistic approach to learning. It fosters interdisciplinary education, addressing a spectrum of formal and informal educational levels from early childhood to postdoctoral studies(Baran et al., 2021).Conversely, the understanding of STEM differs among educators, educational researchers, curriculum developers, and policymakers. Besides, educators hold diverse perspectives on STEM, with some seeing it as a novel approach to teaching STEM subjects, while others perceive it as a new curriculum or program(Madani, 2021). Previous studies presented various perspectives on the integration of STEM education into science education. Some emphasized the unification of all STEM disciplines by establishing explicit connections in content areas or incorporating interdisciplinary content. This approach aimed to offer learners more relevant, cohesive, and engaging experiences, moving away from fragmented learning scenarios(Suleiman, 2021). The increasing demand for STEM expertise has led to concerns about the quality of STEM education worldwide. Recent U.S. educational reforms, including the Framework for K-12 Science Education and the Next Generation Science Standards, emphasize integrated STEM education to enhance student engagement and interest in STEM fields(Wieselmann, Sager, 2022).

On the other hand, other scholars stressed that the integration of STEM should pivot towards student-centered teaching methods, involving authentic, real-world problems that encourage active learning(Kang, 2019). Moreover, numerous research studies concentrated on

using particular teaching methods to integrate STEM, such as inquiry-based learning, problem-based learning, or project-based learning (Belbase et al., 2022). However, those opposing the integration process hold a dissenting view, expressing concerns about adopting an approach that necessitates restructuring various elements (Hamad et al., 2022). This includes the training of STEM teachers and altering the structure of educational programs, extending to the revision of assessment methods. Notably, the time investment required for implementing such substantial changes serves as a barrier to this reform (Hamad et al., 2022). Furthermore, educational researchers suggest that teachers encounter challenges in establishing connections between the STEM disciplines (Hamad et al., 2022). We advocate for the implementation of STEM integration through student-centered teaching, which encourages increased engagement and active learning strategies.

Several research studies have explored the impact of STEM integration on students' interest and engagement in science learning, as well as their inclination toward STEM careers (Hamad et al., 2022). Xie, Fang & Shauman (2015) argues that STEM education is geared toward producing graduates equipped with the necessary skills to excel in a technologically oriented future workforce. Additionally, Kant, Burckhard & Meyers (2018) contended that integrated STEM education serves as a platform for cultivating essential personal and professional competencies. These competencies include research inquiry, problem-solving, critical and creative thinking, collaboration, teamwork, and communication. Moreover, proper STEM education contributes to the improvement of technical knowledge (Madani, 2021).

In response to contemporary challenges such as energy crises, economic downturns, technological advancements, and climate change, there is a compelling need for transformative

educational approaches. STEM education emerges as a potent solution to these multifaceted issues. By emphasizing sciences, mathematics, engineering, and technology, it ensures a robust educational foundation tailored to address real-world problems. Consequently, it cultivates a generation equipped with essential skills to navigate present and future complexities, thereby contributing to societal advancement and elevating the economic landscape of the nation (Murshidi, 2019). Therefore, improved STEM education is crucial for the progress and economic stability of numerous countries, given the social and environmental challenges of the 21st century (Jarrar, 2020). Consequently, education in the GCC is transitioning towards STEM-based education. Educators are now under pressure to adopt innovative teaching methods, departing from abstract problems and traditional instructions that have contributed to a lack of motivation, and overall low performance among GCC students in STEM subjects (Madani, 2021). Nevertheless, it has come to light that students' diminished enthusiasm for STEM subjects stems from the predominant use of traditional instructional methods, placing excessive emphasis on textbooks. In contrast, innovative instructional strategies like inquiry-based learning tend to be overlooked or neglected (Madani, 2021).

However, UAE places a strong emphasis on the belief that innovation thrives through ongoing enhancement, fostering curiosity, embracing risk, and encouraging inquiries. Studies have demonstrated that integrated curricula in STEM contribute to a more positive educational experience for students by connecting various disciplines in a way that is relevant to everyday life. This approach fosters improved critical thinking and problem-solving skills, leading to enhanced retention levels. However, numerous studies in science education have predominantly concentrated on reform endeavors, overlooking the holistic comprehension of the interplay among educators and curriculum designers within a collaborative environment

conducive to discussions on scientific thinking. The successful amalgamation of mathematics and science disciplines hinges significantly on educators' understanding, depth of content knowledge, and perspectives regarding the integration process (Madani, 2021). According to (Kelley, T. R., Knowles, 2016), integrative STEM is characterized by engaging learners in a comprehensive curriculum that includes interconnected instructions in science, mathematics, and engineering design. The primary goal is to apply these disciplines collaboratively to address real-life problems. Alternatively, Hamad et al. (2022) noted that acquiring knowledge in science and mathematics through an integrated engineering design process not only improves critical thinking skills but also fosters a keen interest in pursuing careers in science and engineering.

2.2.2 Project Based Learning

Project-Based Learning or PBL, is an instructional method that requires students to conduct group research within a specified timeframe, addressing real-life, intricate, and challenging problems, thereby enabling them to structure their knowledge systematically through teamwork and problem-solving (Baran et al., 2021). Besides, the idea of Project-Based Learning (PBL) is connected to constructivism principles that arise from the pragmatic, cognitive, and social constructivist perspectives found in Dewey's philosophy (Agudelo & Vasco, 2019). Haddad (2022) affirms the positive outcomes of project-based learning (PBL), noting its ability to enhance critical thinking and student motivation. Additionally, it contributes to the professional development of teachers, fostering creativity and a willingness to learn in response to evolving curricula and educational approaches. Despite the challenge of time constraints, PBL introduces teachers to effective time management strategies. The

student-centered nature of project-based learning PBL minimizes the need for extensive teacher explanations, promoting increased student engagement in the learning process(Haddad, 2022). Furthermore, Agudelo and Morales-Vasco (2019) conducted research to assess the effectiveness of project-based learning (PBL). They investigated its impact on students previously characterized as inattentive, easily distracted, and unwilling to engage in suggested activities, with limited awareness of their future prospects. Following the implementation of PBL, significant positive changes were evident in their behavior and attitudes toward learning. These students displayed heightened responsibility, punctuality, commitment, and honesty, reflecting an increased sense of accountability. The improved awareness of their role in the classroom contributed to a more positive perspective on education(Agudelo & Vasco, 2019).

Viro (2020) emphasized that the primary goal of PBL is to aid students in cultivating not just their subject-specific knowledge but also success skills, commonly referred to as 21st-century skills. The emphasis lies in the application of subject knowledge in practical scenarios during the project. Consequently, students enhance their understanding of subjects through the utilization of various skills, including critical thinking, problem-solving, collaboration, and self-management(Viro, 2020). In a study conducted by Ayu, Pradnyani & Giri (2021), an improvement in critical thinking skills was observed with the implementation of PBL. Furthermore, PBL contributed to enhancing students' abilities to analyze, evaluate, and foster creativity. Additionally, Zheng Zheng et al. (2021) conducted research that indicated PBL's positive impact on students' problem-solving capabilities. In an outdoor learning environment, students engaged in PBL, where questions and suggestions from teachers and peers generated problems. Students showcased their acquired knowledge through PBL, sharing their work with peers, teachers, and visitors, leading to positive attitudes toward learning and substantial effort

invested in PBL projects(Zheng et al., 2021). In a study by Warr and West (2020), it was observed that students exhibited better learning outcomes with PBL compared to traditional learning methods. PBL provided students with valuable experiences in meeting deadlines and collaborating effectively with their peers. The importance of communication skills was emphasized, and students recognized the necessity of integrating various disciplinary studies to successfully complete their projects within the PBL framework(Warr and West, 2020).

Maria Montessori, a proponent of independent education, resonates with the fundamental principles of project-based learning (PBL)(Viro, 2020) . Her emphasis on nurturing children's autonomy and motivation aligns seamlessly with the core views of PBL. Montessori put her philosophy into practice by providing children with unrestricted access to materials, allowing freedom of movement, and prioritizing uninterrupted work. In the Montessori curriculum, students are empowered to learn at their own pace, guided by teachers who facilitate the process(Haddad, 2022). This educational approach empowers students to take the lead, self-assess, and delve into concepts comprehensively. Montessori advocated that granting students the liberty to question and establish connections fosters the development of confident and self-directed learners(Haddad, 2022).

PAN and SEOW (2019) highlighted that PBL not only allowed learners to immerse themselves in real-world experiences but also facilitated collaboration and in-depth research. Within the PBL framework, learners gained greater freedom to explore ideas and showcase their problem-solving skills. Additionally, PAN and SEOW (2019) noted that PBL played a crucial role in teaching learners how to function in real-life environments, fostering their ability to work in informal settings. Students actively engaged in discussions, listened to diverse perspectives, reached decisions through consensus, and navigated disagreements.

Furthermore, according to Pablo Aránguiz and Palau-Salvador(2020), a pivotal aspect of PBL is its capacity to enable students to apply their work to real-life scenarios. In their study, they found that students demonstrated the ability to propose creative solutions based on reliable data, employing various research techniques to address problems. Creative problem-solving became evident as they defined the focus, searched for solutions using inductive processes, and compared evidence while analyzing the information they had gathered(Pablo Aránguiz, Palau-Salvador, 2020).

Prior research has pinpointed several factors contributing to the successful implementation of PBL. Among these, the skills and capability of teachers in guiding students emerge as crucial determinants for PBL success. However, a body of research has highlighted various obstacles to the effective implementation of PBL. These include deficiencies in teachers' understanding, skills, and ability to execute PBL, coupled with their resistance to student-centered instruction(Viro, 2020). Teachers' comprehension of the prerequisites for effective PBL is crucial in determining how they incorporate PBL into their classrooms, and this directly correlates with students' learning outcomes.

2.2.3 Impact of STEM-Project Based Learning Activities on the Enhancement of 21st

Century Skills

As previously noted, in the context of globalization, the expectations for the qualifications of individuals in the 21st century have evolved. While there isn't a singular definition of 21st century skills in the literature, various studies have identified key skills based on the demands of employers and industries for their future workforce(Baran et al., 2021). Incorporating Project-Based Learning (PBL) in STEM education is an active method that

enhances the learning experience of students and equips them with the 21st century skills essential for their future. As a consequence of combining project-based learning (PBL) and STEM approaches, students gain the ability to apply their knowledge across the four disciplines through the projects they undertake. This facilitates meaningful learning and positively influences students' attitudes, potentially increasing their likelihood of pursuing STEM professions in their future careers. Baran et al. (2021) conducted a research on the impact of project-based learning STEM (PjbL-STEM) applications, specifically involving the use of waste materials, on the 21st century skills of 10th-grade students. The study included project-based STEM activities, and the students were divided into groups of three based on their class attendance list order. Each group was assigned STEM projects utilizing waste materials, with one group working on three projects and the remaining groups on two projects, adjusting for project difficulty levels. The findings indicated a significant difference in participants' total scores on the 21st-century skills scale before and after the project applications, these skills include communication and collaboration, creativity and problem solving thus highlighting the influence of project difficulty levels(Baran et al., 2021).Furthermore, according to Fouad's (2018) research, the study delves into the influence of STEM Project-Based Learning on scholars' academic accomplishments and the cultivation of their 21st century skills. The focus of the research is on creating a rover prototype. The study aims to understand how engaging in STEM projects, such as creating a rover prototype, contributes to students' overall learning outcomes and skill development. The findings reveal positive impacts of STEM-PBL on students' attainments, particularly in advancing their 21st century skills, ultimately leading to an enriched learning experience. Additionally, students conveyed a preference for STEM activities over their previous learning approaches(Fouad,

2018). Moreover, Jarrar (2020) investigated the influence of implementing the STEM Project-Based Learning (PBL) approach on the academic achievement of elementary students in science classes in Sharjah, UAE. The findings demonstrated a positive impact of the STEM PBL approach on the academic performance of elementary students in science. Furthermore, the results revealed that the STEM PBL approach positively affected students' motivation, achievement, and the development of their 21st century skills(Jarrar, 2020).

2.2.4 Teachers' Perspectives on Implementing STEM Project-Based Learning on the Enhancement of 21st Century Skills

Educators are critical in the effective implementation of STEM- project based learning. However, the practices of teachers in the STEM domain are profoundly shaped by their perceptions of STEM(Thibaut et al., 2018). A comprehensive examination of studies and literature provides valuable insights into how teachers perceive STEM-project based learning education on the enhancement of 21st century skills. Margot & Kettler (2019) argue that teachers' perceptions of STEM education are influenced by demographics, asserting that age, gender, and educational background impact how teachers view STEM. They contend that a positive attitude towards STEM tends to increase with the teacher's age. Generally, male teachers hold a more favorable opinion of STEM education compared to their female counterparts. Additionally, teachers who have taken more STEM-related courses in college find their jobs in STEM education easier and are better prepared to teach STEM subjects. This perspective contradicts the findings of Srikoom & Hanuscin (2017), who suggested that teachers' backgrounds do not significantly affect their perceptions of STEM education.

However, it aligns with the claims of Park et al. (2016), highlighting the importance of teachers' preparation in influencing STEM education and its implementation.

Concerning the factor of teachers' years of experience, Thibaut et al. (2018) argue that novice teachers tend to express a less positive view of STEM education compared to experienced teachers. On the contrary, Srikoorn & Hanuscin (2017) state that the relationship between teachers' years of experience and their perceptions of STEM education appears inconsistent, and the teacher's interest in STEM education may play a role in this inconsistency.

The subject taught by teachers seems to have a significant impact on influencing their attitudes towards STEM education. For instance, studies indicate that science teachers typically harbor a more favorable outlook and demonstrate higher readiness to incorporate integrated STEM education compared to mathematics educators. Mathematics teachers often perceive challenges in assisting students with solving authentic problems in STEM contexts (Chaya, 2023). Additionally, teachers with varying educational levels acquire distinct levels of knowledge and personal perceptions of STEM education. For instance, those with master's and doctoral degrees tend to demonstrate a better understanding and a more positive view of STEM education, as highlighted by Thi et al. (2020). Similarly, teachers with diverse backgrounds or majors may hold different perceptions of STEM education. Furthermore, teachers recognize the importance of STEM education in fostering students' 21st century skills, including collaboration, creativity, innovation, problem-solving, and technological skills.

Thus, teachers request professional development opportunities, such as workshops, to address the demanding implementation of interactive STEM curricula. The professional development (PD) should focus on the pedagogy of enactment, emphasizing the application of

various student-centered learning approaches techniques as essential components for integrating STEM disciplines(Chaya, 2023).

Moreover, various psychological factors impact teachers' perceptions of teachers in STEM education. One notable factor is the teachers' attitude toward teaching STEM, as it significantly influences their perceptions and practices in STEM education. Attitude, in this context, is considered a crucial construct and a predictive factor that shapes the direction and intensity of future behavior(Chaya, 2023).

The literature review indicates that teachers, particularly prospective teachers, may feel well-versed in PBL theory but lack practical training. Teachers need comprehensive training in both the theoretical and practical aspects of PBL to achieve success in its implementation. There is a consensus that teachers need to transition from being classroom experts to facilitators in a PBL environment. Previous research, such as that conducted by Alrajeh (2020), supports the necessity of practical training in PBL. Alrajeh (2020) emphasizes that courses taken by prospective teachers in college often focus on theory alone. The study suggests that integrating both theoretical and practical experiences in university courses is essential for effective PBL education. Teachers who undergo the PBL process during their college education find it meaningful and valuable(Alrajeh, 2020).Nevertheless Tsybulsky et al. (2020) examined the experiences of preservice educators in their foundational year of engaging in a PBL process. The research examined both the quality of the experience and the shifts or improvements in that quality over time. The findings demonstrated that preservice teachers navigated through distinct stages, encompassing frustration, handling with challenges, achieving achievement, and ultimately attaining fulfilment, contributing to the development of confidence. Despite facing challenges in implementing PBL, the study underscored the

significance of effectively dealing with difficulties, leading to positive experiences. The research concluded that preservice teachers perceived PBL as rewarding, yet there was acknowledged need to bridge the gap between theory and practice, especially through teacher modeling, particularly for novice teachers (Tsybulsky et al. 2020).

Additionally, teachers benefit from a supportive team environment. Success with PBL is often associated with a focus on developing soft skills, including effective communication and collaboration within peer groups (Macmath et al., 2017). Moreover, administrative support plays a crucial role in the successful implementation of Project-Based Learning (PBL) in the classroom. When teachers receive support from administrators through policies and assessments that align with PBL goals, it positively influences their perceptions of PBL. According to Susanti et al. (2020), teacher perceptions during PBL implementation contribute significantly to their success. When teachers feel supported by administrators, they exhibit increased satisfaction with teaching, enhanced enthusiasm, confidence, and improved critical thinking skills. This support is vital for overcoming challenges and ensuring the success of PBL projects (Susanti et al. 2020).

An essential aspect to incorporate into preservice training for PBL teachers is the understanding of students' diverse cultures and backgrounds. Petersen (2020) emphasize the importance of being mindful of students' backgrounds, as varying opinions may arise within working groups due to cultural diversity. Furthermore, Brundiers & Wiek (2013) conducted a study on the benefits of PBL for science students, identifying key areas in science classrooms where teacher training is essential for the successful implementation of PBL. They emphasized the need for more active involvement of science education in PBL opportunities for students. Effective collaboration between teachers and scientists was identified as crucial for a PBL

science classroom to function optimally. Aligning PBL activities with existing curriculum content is crucial.

Addressing challenges through collaborative problem-solving is inherently tied to student-centered learning. Effective training for teachers should prioritize the facilitation of this learning approach. Throughout professional development initiatives, educators need chances to engage with PBL. It is crucial for teachers to gain a profound understanding of what active, student-centered learning involves (Grossman et al., 2019).

While research on STEM-Project-Based Learning has demonstrated positive outcomes in terms of academic achievement and affective dimensions, it is not without its challenges. Teachers face several hurdles in implementing STEM-PBL effectively. The difficulties included the creation of challenging curricula, as textbooks were not utilized in lesson planning. Implementing PBL within school schedules posed challenges, as it requires more time than traditional education and lack of financial support. Additionally, preservice teachers carried biases towards PBL as they commenced teaching (Aldabbus 2018). Moreover, the curriculum was not originally structured for STEM-Project-Based Learning (PBL) instruction (Aldabbus, 2018).

Hence, educators need to explore ways to adapt and contextualize the lesson content to align with PBL, ensuring that the lesson objectives remain intact. Additionally, research by Vasiliene-Vasiliauskiene et al. (2020) highlights that teachers facing challenges with PBL may need time to adapt, particularly when the approach conflicts with established beliefs about teaching.

Upon reviewing the relevant literature, it becomes evident that STEM-project based learning education is instrumental in cultivating 21st century skills, including problem-solving

and critical thinking. (SURATNO et al., 2020), and the creative process skills (Parmin & Sajidan, 2019).

Chapter 3: Methodology

In the 21st century, STEM project-based learning has garnered global attention among educators. In recent years, the UAE has witnessed a considerable increase in national programs fostering innovation in STEM, empowering schools to implement STEM initiatives. The primary objectives of these STEM PBL programs include equipping students with essential skills vital for their personal and academic growth, such as creativity, problem-solving, communication, critical thinking, collaboration, and innovation.

The current study aims to investigate the impact of implementing STEM project-based learning on 21st century skills in private schools in Ajman, UAE. This chapter outlines the development and methodology of the research, encompassing eight units that delve into the research design, population and sample selection, research instruments, reliability, validity, research procedure, data analysis, and ethical considerations.

3.1 Research Design

Creswell (2017) characterizes the mixed-method approach as a research strategy that integrates both qualitative and quantitative methodologies. In this study, an explanatory sequential mixed-methods approach was adopted, with an initial emphasis on the quantitative model. This choice of mixed-methods design was deliberate, aiming to thoroughly address the research questions. Considering the constraints of limited research time, an ideal strategy involves commencing with an exploratory qualitative design followed by an explanatory quantitative design.

The rationale for employing a mixed-method approach lies in its capacity to conduct a comprehensive exploration of the study's themes, facilitating the application of results to a broader population (Dawadi & Giri, 2021). The study took place in Private American Schools in Ajman, UAE.

Quantitative data from science, math, and ICT teachers were collected through a questionnaire. Additionally, a qualitative approach was employed, involving semi-structured interviews and open-ended questions designed specifically for science, math, and ICT teachers. Quantitative data, derived from closed-ended sources like tests and surveys, enables a broad examination across a large participant pool. In contrast, qualitative data, acquired from open-ended sources, provides a deeper understanding, adding depth to the study while quantitative data offers breadth (Dawadi & Giri, 2021).

The study approach is rooted in philosophical underpinnings that guide its qualitative and quantitative components. Informed by constructivist theory, the qualitative aspect utilizes interviews and open-ended questions to gather insights from teachers, aligning with the idea of constructivism, particularly Vygotsky's theory, which emphasizes teachers' pivotal role in guiding students within their Zone of Proximal Development (ZPD) through scaffolding. Conversely, the quantitative component adheres to positivist theory, employing an empirical study with closed-ended questionnaire items to investigate teachers' perceptions regarding STEM project-based learning (PBL) and its impact on 21st century skills.

In education, Integrative Theory refers to an approach that combines elements, concepts, or disciplines into a unified framework. The study explores three integration approaches—interdisciplinary, multidisciplinary, and transdisciplinary—in the context of STEM education. Interdisciplinary integration merges knowledge, methodologies, and perspectives from multiple

subjects around a theme, enhancing understanding and skill development. In STEM PBL, interdisciplinary integration facilitates transformative learning experiences by exposing students to diverse perspectives and real-world challenges.

Social-Cognitive Constructivist Theory, notably Vygotsky's ideas, underscores the importance of social interaction in learning and the role of teachers in guiding students within their ZPD through scaffolding. This approach emphasizes individualized support, active learning, and collaborative problem-solving, aligning with the principles of STEM PBL.

Constructivism Theory, championed by Dewey and extended by Papert, promotes learner-centered instruction and active engagement in hands-on activities. STEM PBL, influenced by Dewey's project method and Kilpatrick's curriculum design, encourages students to actively construct knowledge through collaborative projects centered around significant themes.

3.2 The Research Population and Sample

The entire study population consists of middle, elementary, and high school teachers with expertise in Science, Math, and ICT, affiliated with Ajman schools during the second semester of the academic year 2023-2024, totaling 116. Participants, voluntarily chosen from various Ajman schools, were selected based on their consent to participate. The study is implemented using a sample derived from this population, inclusive of both male and female teachers across elementary, middle, and high school levels, employing a convenience sampling method. Homeroom teachers responsible for Grade 1 to Grade 3 completed the survey both in their roles as science teachers and as math teachers.

3.3 Instruments of the study

The current study utilized a questionnaire, interviews, and open-ended questions, all developed by the researcher. The tools are detailed as follows: For this research, a questionnaire comprising four sections was employed:

1. The initial section aimed to gather demographic information (gender, age, teaching experience, academic qualification, grade level you instruct and subject taught) from the science, math, and ICT instructors involved in the study.

2. The initial tool employed in the research was a questionnaire designed to elicit insights from science, math, and ICT instructors regarding their perceptions and practices of implementing STEM Project-Based Learning and its impact on enhancing 21st century skills. The questionnaire items were crafted by the researcher, drawing upon a review of various prior studies related to the current research (Park et al., 2016), (Hamad et al., 2022), (Aldabbus, 2018) and (Haddad, 2022). Special attention was given to examining the tools utilized in these studies, with a particular focus on similar investigations.

Respondents used a five-point Likert scale to provide answers to the tool's items. The 5-point Likert scale encompassed the following options: (1) strongly disagree; (2) disagree; (3) neutral; (4) agree; and (5) strongly agree. The questionnaire focused on exploring the perceptions and practices of elementary, middle, and high school science, math, and ICT instructors regarding the impact of STEM Project-Based Learning on 21st century skills. The questionnaire is structured into five categories. The first category pertains to impact of STEM PBL on 21st Century Skills. The second focuses on instructors' instructional integration, the third on instructor engagement, the fourth on professional development, and the last one on the

challenges they encounter related to its implementation. The first category comprises seven items focusing on the impact of STEM project -based learning on 21st century skills. The second category, consisting of three items, explores teachers' instructional integration. The third category, with three items, delves into teachers' engagement. The fourth category, featuring two items, addresses teachers' professional development. Finally, the fifth category, encompassing three items, explores the challenges encountered by teachers when implementing STEM project-based learning for 21st century skills.

The preliminary version of the questionnaire underwent evaluation by an expert in science education at the British University (BUID). Following the expert's recommendations and suggested modifications, certain items in the questionnaire were adjusted (refer to Appendix A).

3. Closed-ended Questions:

To enhance, validate, and refine the quantitative data, four open-ended questions were included, aligning with the questionnaire's five dimensions. These questions explored the integration of instructional methods by teachers, levels of engagement, with professional development, and encountered challenges. (refer to Appendix B).

3. Semi-Structured Interview:

Due to the exploratory nature of qualitative research and the desire to gather more in-depth data, many qualitative researchers choose for semi-structured interviews (De Fina 2019). Semi-structured interviews are characterized by informality and the use of open-ended questions, blending elements of both structured and unstructured approaches (George 2023). Face-to-face interviews offer the advantage of establishing a rapport with respondents,

allowing the researcher to collect richer and more confidential data compared to questionnaire methods (Leavy 2017).

To delve deeper into educators' perceptions and practices regarding the implementation of STEM project-based learning, and to complement the questionnaire data, interviews were conducted. Four teachers who also serve as leaders in the fields of math, science, and ICT, had responded to the questionnaire, and agreed to participate in interviews. The interviews (see Appendix C) comprised 7 yes-or-no questions, accompanied by a request for justifications from the instructors. Meetings were arranged with the interviewed instructors at their workplaces, and in some cases, telephone calls were used. Each interview lasted 10-15 minutes.

3.4 Reliability of the Questionnaire

This study employed two methods to assess the reliability of the questionnaire. The first method utilized the Cronbach's alpha formula, which evaluates the tools' consistency, while the second method involved a test-retest approach to determine the stability of the tool. For this reason, a pilot study was conducted. Creswell (2017) highlights Cronbach's alpha as a widely employed test for assessing the internal consistency of participants' responses, making it a suitable choice for this study. To ensure the effectiveness of the questionnaire, a pilot study involving 30 science, math, and ICT teachers from various schools in Ajman was conducted.

The aim was to assess the clarity and understanding of each research item, mitigating potential language and meaning-related confusion that could impact the research results. Cronbach's alpha was utilized to gauge the reliability of the research instrument during this pilot study.

As per (Rahman, 2020), reliability coefficients equal to or exceeding 0.70 are generally deemed satisfactory in social research studies. The data analysis in the current study revealed a Cronbach Alpha value equal or surpassing 0.70. Consequently, the instrument employed in this study demonstrates satisfactory reliability and is deemed suitable for the research.

Table 1

Cronbach's Alpha of the Questionnaire

Refined Questionnaire and its sections	Item	Cronbach's alpha (Consistency Index)
STEM PBL on 21 st Century Skills	7	0.938
Teachers' Instructional Integration	3	0.700
Teachers' Professional Development	2	0.700
Teachers' Challenges	3	0.875
Teachers' engagement	3	0.702

According to Table 1, the STEM PBL on 21st Century skills has a very good internal of consistency, with a Cronbach alpha coefficient reported of 0.938 above 0.70 with 7 items. The Teacher's engagement has a good internal of consistency, with a Cronbach alpha coefficient reported of 0.702 above 0.70 with 3 items. The Teacher's professional development with a Cronbach alpha coefficient to 0.70 which shows a good internal of consistency of the scale with 2 items. Teacher's challenges have a very good internal of consistency, with a Cronbach alpha coefficient reported of 0.875 above 0.70 with 3 items. The teachers'

instructional integration with a Cronbach alpha coefficient to 0.70 which shows a good internal of consistency of the scale with 3 items.

Examining the reliability of a research tool through correlation coefficient, test-retest is employed, as suggested by Johnson (2014). The Pearson correlation factor was computed to assess the test's reliability. The outcomes are presented in Table 2.

Table 2

Pearson Correlation

Variable	1	2	3	4	5
STEM PBL on 21 st Century Skills		-.770**	.779**	.639**	.518**
Teachers’ Instructional Integration	-.770**		-.547**	-.373*	-.383*
Teachers’ Professional Development	.779**	-.547**	-	.400*	.628**
Teachers’ Challenges	.639**	-.373*	.400*		.557**
Teachers’ Engagement	.518**	-.383*	.628**	.557**	

**Sig<0.01; *Sig α <0.05

According to Table 2, there is a negative strong significant correlation between STEM and teacher’s instructional integration, $r = -0.770$; $\text{sig} < 0.01$. The correlation between STEM and

teacher's professional development was positive strong and significant, $r=0.779$; $\text{sig}<0.01$. Moreover, the correlation between STEM and teacher's challenge was also positive strong and significant with $r=0.639$, $\text{sig}<0.01$. Finally the Pearson correlation between STEM and Teacher's challenge was also positive significant and strong, $r=0.518$, $\text{sig}<0.01$.

The outcome of the calculations indicates that the questionnaire is suitable for achieving the intended purpose of the application.

3.5 Validity of the Questionnaire

Validity is a valid approach characterized by the measure's clarity, relevance, difficulty, and sensitivity to its intended audience (Allen et al., 2023). Therefore, in crafting the questionnaire for this study, efforts were made to enhance clarity and overall appropriateness by carefully selecting clear and understandable words and concepts, eliminating any potential uncertainties.

In this study, content validity was employed to ensure the appropriateness of the questionnaire. A test achieves validity when its items effectively measure the intended construct (Roebianto et al., 2023). To validate the content, the research instrument underwent evaluation by an expert specialized in science education and analysis. Consequently, the experts' suggestions and adjustments were taken into account, leading to the final version of the questionnaire comprising five categories with 18 items.

3.6 Research Procedure

The study progressed through distinct stages. Initially, a teachers' questionnaire, consisting of both closed and open-ended questions, was developed and received approval

from the administration of each participating school. Subsequently, an email containing the questionnaire was sent to science, math, and ICT teachers in elementary, middle, and high schools, outlining the study's objectives and inviting their participation. The teachers were informed about the study's goals and the required actions for responding to the questionnaire.

Teachers completed the task and returned the questionnaires after providing their responses. Upon collecting the responses, the data were coded and entered into the statistical software IBM SPSS 27 for processing. The study's results were then subjected to statistical analysis, followed by a comprehensive discussion. Subsequently, recommendations and suggestions were formulated based on the research findings.

Concerning interview procedures, four teachers with leadership roles were interviewed. Each teacher was contacted via phone to schedule a convenient interview time at the school, adhering to established interview protocols.

3.7 Data Analysis

Quantitative (questionnaire) and qualitative (open-ended questions and semi-structured interviews) data were analyzed to answer the research questions. Following an explanatory sequential approach, the quantitative data was assessed first for a general understanding, followed by the qualitative data for added depth. After pre-coding in SPSS software, descriptive statistics were used to gather insights from the findings. In relation to the open-ended questions, a rubric was applied to assess the responses. The answers were coded and entered for processing.

3.8 Ethical Considerations

Confidentiality involves safeguarding the privacy and security of participants' data throughout the entire research process. It is imperative in maintaining the integrity of the user-research process. Researchers must emphasize and clarify two crucial points to participants: the protection of data privacy and the maintenance of participant anonymity. These aspects should be explicitly outlined in the researcher-participant agreement before initiating data collection.

Adherence to the Data Protection Act is essential for handling and storing all information securely. Access to the data should be limited to the researcher alone. Written and audio records will be securely stored in an reachable location(Mirza et al., 2023).The gathering and analysis of data carry inherent risks; however, neither the conclusions nor the collected data contain any personal information from the field or schools. Questionnaire contents are kept private, ensuring responders' answers remain anonymous.

Ethical concerns were addressed in accordance with the guidelines of the British University of Dubai. Prospective participants were informed about the research objectives, associated risks, and benefits before deciding to participate. Participants received a personal information form with a disclaimer ensuring non-disclosure of their names. Even if cited, the data would remain anonymous, preserving the confidentiality of individuals (Wexler & Largent, 2023).

Rigorous provisions were implemented to maintain the confidentiality of students' and teachers' engagement in UAE. Participants had the freedom to withdraw from the study at any point, and data collected at any level of the study was not shared to protect participant privacy. The British University of Dubai Study Handbook's terms and conditions emphasized that the

research would not cause harm to the respondents. Refer to BUiD's ethic application (or approval) in appendix D.

The research involved two levels of contact: an official letter from the university authorizing the surveys at designated sites in the UAE and obtaining written consent from the relevant schools to ensure a seamless survey. Participants' personal information and privacy, along with school names, will be confidential and anonymous, used solely for research purposes(Creswell, 2017).

Chapter 4: Data Analysis and Results

This chapter reveals the outcomes of the investigation and the statistical data that underwent analysis using Statistical Package for Social Sciences IBM (SPSS) version 27.0. It presents a thorough examination of the results derived from the integration of both qualitative and quantitative data. To accomplish this, a mixed-methods approach was employed. The quantitative facet encompasses a survey administered to teachers, including open-ended questions, while the qualitative dimension involves conducting interviews with leaders.

4.1 The Study Results

This study investigated teachers' perspectives on the implementation and practices of STEM project-based learning on 21st century skills within private schools in Ajman, UAE. Additionally, it examined how factors such as gender, age, academic qualifications, teaching experience, grade level, and subject taught influence educators' perceptions on the role of STEM project-based learning in enhancing 21st century skills.

4.2 Demographic Information of the Questionnaire

Table 3 presents information on the number, distribution, and characteristics of the samples. Out of the total sample, 88 teachers, accounting for 75.9%, were female, while 28 teachers, constituting 24.1%, were male. The majority of respondents, 80 teachers (69%), were aged over 30 years, with 27 teachers (23.3%) falling in the 25-30 age range, and 9 teachers (7.8%) being less than 25 years old. In terms of teaching experience, 33 teachers (28.4%) had over 15 years of experience, a number identical to those with 11-15 years of experience, while 26

teachers (22.41%) had 6-10 years of experience, and 24 teachers (20.7%) had 1-5 years of experience. Regarding education, 57 respondents (49.14%) held a bachelor's degree, followed by 37 teachers (31.90%) with a Master's degree, and 22 teachers (18.97%) with a diploma. Concerning teaching levels, 41 respondents (35.3%) were high school teachers, 38 (32.8%) were elementary teachers, and 37 (31.9%) were middle school teachers. In terms of majors, 48 respondents (41.38%) were in the math field, 47 teachers (40.52%) were in the science field, and 21 teachers (18.10%) were in the ICT field.

Table 3

Distribution and Percentage of Demographic Categorical Variables

Variable	Category	N	% percentage
Gender	Female	88	75.9
	Male	28	24.1
Age	Less than 25 years	9	7.8
	25-30 years	27	23.3
	More than 30 years	80	69.0
Teacher Experience	1-5 years	24	20.7
	6-10 years	26	22.4
	11-15 years	33	28.4
	More than 15 years	33	28.4
Academic Qualifications	Bachelor	57	49.1
	Diploma	22	19.0
	Master's	37	31.9
Grade level you instruct	Elementary	38	32.8
	Middle	37	31.9

	High	41	35.3
	ICT	21	18.1
Major subject	Math	48	41.4
	Science	47	40.5
Total		116	100.0

4.3 Results Related to Question 1

What are educators' perceptions regarding the implementation of STEM project-based learning in enhancing 21st century skills in private American schools in Ajman, the United Arab Emirates? To address these questions, means, standard deviations, frequencies, and percentages for each category and item were used. The table below provides an overview of the results:

Table

Frequency , Mean ,Standard Deviation,and Percentage of the Perceptions of Educators on the implementation of STEM PBL on 21st Century Skills

Item		Frequency	Percentage	Mean	Standard deviation
Implementing STEM project-based learning in my teaching improves students' problem-solving skills.	SD	3	2.6	4.28	0.809
	D	1	.9		
	N	5	4.3		
	A	59	50.9		
	SA	48	41.4		
STEM project-based learning serves as a key factor in	SD	3	2.6		
	D	1	.9		

nurturing and enhancing students' critical thinking abilities.	N	5	4.3	4.25	0.801
	A	62	53.4		
	SA	45	38.8		
Applying STEM project -based learning in education is crucial for promoting collaboration among students.	SD	2	1.7	4.29	0.710
	D	1	.9		
	N	2	1.7		
	A	67	57.8		
	SA	44	37.9		
Applying STEM project -based learning in education is crucial for promoting communication among students.	SD	1	.9	4.25	0.696
	D	2	1.7		
	N	5	4.3		
	A	67	57.8		
	SA	41	35.3		
Applying STEM project-based learning, students can articulate a problem and actively seek innovative solutions.	SD	2	1.7	4.22	0.695
	D	-	-		
	N	6	5.2		
	A	71	61.2		
	SA	37	31.9		
Incorporating technology plays a valuable role in promoting creativity in STEM project-based learning education.	SD	2	1.7	4.22	0.674
	D	-	-		
	N	4	3.4		
	A	74	63.8		
	SA	36	31.0		
Incorporating technology during STEM project-based learning provides students with an interactive and innovative educational experience.	SD	2	1.7	4.31	0.690
	D	-	-		
	N	3	2.6		
	A	66	56.9		

	SA	45	38.8
Total		116	100

Table 4 displays the means, standard deviations, and percentages reflecting educators' perceptions and practices of the implementation of STEM PBL on 21st century skills. The results provide a descriptive analysis of participants' responses to the questionnaire, where (SA) indicates strongly agree, (A) signifies agree, (N) denotes uncertain, (D) represents disagree, and (SD) stands for strongly disagree (refer to the questionnaire in Appendix A). The detailed analysis of the table underscores a consistent trend of agreement among educators, with a significant percentage expressing positive views on various aspects of STEM project-based learning. Specifically, 50.9% of participants agree that the implementation of STEM project-based learning contributes significantly to enhancing students' problem-solving skills, as evidenced by a mean score of 4.28. Additionally, a significant 53.4% recognize the pivotal role of STEM project-based learning in fostering and improving students' critical thinking abilities, with a mean score of 4.25. Furthermore, the majority, at 57.8%, agrees on the crucial role of STEM project-based learning in promoting collaboration among students, reflected in a mean score of 4.29. This consensus extends to the promotion of communication among students as well, with a mean score of 4.25. Moreover, 61.2% of educators agree that students can proficiently articulate problems and actively seek innovative solutions within the framework of STEM project-based learning, supported by a mean score of 4.22. The importance of technology in fostering creativity is acknowledged by 63.8% of respondents, with a mean score of 4.22. The statement "Incorporating technology during STEM project-based learning provides students with an interactive and innovative educational experience"

received the highest mean score of 4.31, with 56.9% agreement, while 1.7% expressed strong disagreement.

Table 5

Frequency, Mean, Standard Deviation, and Percentage of the Teacher's Perceptions About Instructional Integration Items on the Implementation of STEM PBL on 21st Century Skills

Item		Frequency	Percentage	Mean	Standard Deviation
There is a lack of well-defined guidelines for the successful implementation of the interdisciplinary approach (STEM PBL).	SD	1	.9	3.78	0.832
	D	10	8.6		
	N	19	16.4		
	A	69	59.5		
	SA	17	14.7		
Incorporating STEM Project-Based Learning (PBL) into my teaching practice is evident in my planning.	SD	-	-	3.94	0.714
	D	6	5.2		
	N	15	12.9		
	A	75	64.7		
	SA	20	17.2		
Engaging students in STEM project-based learning equips them not only with marketable skills but also with the ability to effectively address real-world challenges.	SD	1	0.9	4.22	0.661
	D	-	-		
	N	9	7.8		
	A	68	58.6		
	SA	38	32.8		
Total		116	100		

Table 5 indicates that 59.5% of teachers expressed agreement with the statement that there is a lack of well-defined guidelines for the successful implementation of the interdisciplinary approach (STEM PBL), with 16.4% being uncertain and a mean score of 3.78.

Moreover, 64.7% agreed that the incorporation of STEM Project-Based Learning (PBL) into their teaching practice is evident in their planning, with a mean score of 3.94. Additionally, 58.6% agreed that engaging students in STEM project-based learning not only equips them with marketable skills but also with the ability to effectively address real-world challenges, representing the highest mean of 4.22, while 0.9% expressed strongly disagreement.

Table 6

Frequency , Mean, Standard Deviation, and Percentage of the Teachers' Perceptions About Engagement Items on the Implementation of STEM PBL ON 21st Century Skills

Item		Frequency	Percentage	Mean	Standard Deviation
Collaborating with teachers from different disciplines poses challenges, particularly in terms of limited cooperation and coordination.	SD	4	3.4	3.92	0.876
	D	4	3.4		
	N	13	11.2		
	A	71	61.2		
	SA	24	20.7		
Collaborating with colleagues from diverse subjects enhances my teaching experience.	SD	1	.9	4.22	0.686
	D	1	.9		
	N	8	6.9		
	A	67	57.8		
	SA	39	33.6		
Engaging with STEM initiatives, supported by the administration, positively influences my teaching effectiveness.	SD	3	2.6	4.13	0.741
	D	-	-		
	N	7	6.0		
	A	75	64.7		
	SA	31	26.7		

Total

116

100

Table 6 reveals that 61.2% of teachers agree with the statement that collaborating with teachers from different disciplines poses challenges, particularly in terms of limited cooperation and coordination, with a mean of 3.92. Additionally, 57.8% agree, with the highest mean of 4.22, that collaborating with colleagues from diverse subjects enhances their teaching experience. Furthermore, 64.7% agree, with a mean of 4.13, that engaging with STEM initiatives supported by the administration positively influences their teaching effectiveness in implementing 21st century skills. limited cooperation and coordination, with a mean of 3.92.

Table 7

Frequency , Mean, Standard Deviation, and Percentage of the Teachers' Perceptions About Professional development Items on the Implementation of STEM PBL on 21st Century Skills

Item		Frequency	Percentage	Mean	Standard Deviation
I believe additional training in STEM PBL practices is essential to enhance students' outcomes	SD	1	.9		
	D	2	1.7		
	N	3	2.6	4.28	0.683
	A	67	57.8		
	SA	43	37.1		
Professional training sessions on STEM-based contextual learning are necessary for teachers to improve their technological skills.	SD	1	.9		
				4.32	0.705
Total		116	100		

Table 7 indicates that 57.8% of teachers agree, with a mean of 4.28, that additional training in STEM PBL practices is essential to enhance students' outcomes. Additionally, 50% agree, with the highest mean of 4.32, that professional training sessions on STEM-based contextual learning are necessary for teachers to improve their technological skills, and 42.2% strongly agree with this statement regarding the impact of STEM PBL on 21st century skills.

Table 8 provides a clear overview, indicating that 61.2% of teachers, with a mean of 4.13, agree that they face challenges in implementing STEM PBL. Teachers express that the lack of resources, including financial constraints and time limitations, poses obstacles in adopting new instructional approaches, such as STEM project-based learning for 21st century skills. Additionally, 54.3% agree, with 34.5% strongly agreeing (highest mean of 4.16), that implementing new ideas is challenging due to the demanding workload associated with teaching, including assessments and examinations. Moreover, 56.0% of teachers find it challenging to incorporate STEM Project-Based Learning (PBL) into their teaching practices, with 23.3% strongly agreeing and a mean of 3.91.

Table 8

Frequency , Mean, Standard Deviation, and Percentage of the Teachers' Perceptions About Challenges Items on the Implementation of STEM PBL on 21st Century Skills

Item	Frequency		Percentage	Mean	Standard Deviation
The lack of resources, both in terms of finances and time, poses a challenge for teachers in adopting new instructional approaches, including STEM	SD	3	2.6	4.13	0.797
	D	2	1.7		
	N	6	5.2		
	A	71	61.2		

project-based learning on 21 st century skills.	SA	34	29.3		
Implementing new ideas is challenging for teachers due to the demands, workload, and tasks associated with teaching, including assessments and examinations.	SD	2	1.7		
	D	5	4.3	4.16	0.840
	N	6	5.2		
	A	63	54.3		
	SA	40	34.5		
Teachers find it challenging to incorporate STEM Project-Based Learning (PBL) because the curriculum lacks a built-in framework for this approach.	SD	3	2.6		
	D	7	6.0		
	N	14	12.1	3.91	0.910
	A	65	56.0		
	SA	27	23.3		
Total		116	100		

Table 9

Mean and Standard Deviation of the Scale Variables

Variable	N	Minimum	Maximum	Mean	Standard Deviation
STEM PBL on 21 st Century Skills.	116	1	5	4.26	0.606
Teachers' Instructional Integration	116	1	4	2.54	0.462
Teacher's engagement	116	1	5	4.09	0.594
Teacher's professional development	116	1	5	4.30	0.649

Teacher's challenge	116	1	5	4.07	0.725
------------------------	-----	---	---	------	-------

The data provides insights into participants' perceptions across multiple dimensions related to STEM education. In the variable "STEM PBL on 21st century skills," participants, on average, rated their perceptions highly, with a mean of 4.26. This suggests a strong positive outlook on the effectiveness of STEM Project-Based Learning (PBL) in fostering 21st century skills among students. The relatively low standard deviation of 0.606 indicates that these perceptions are consistent among the respondents, and the scores range from a minimum of 1 to a maximum of 5.

Moving to "Teachers' Instructional Integration," participants, on average, provided a mean rating of 2.54. This suggests a moderate level of instructional integration in their teaching practices. The standard deviation of 0.462 indicates some variability in responses, and the scores range from a minimum of 1 to a maximum of 4.

In the "Teacher's engagement" category, participants reported a high level of engagement, as reflected by the mean of 4.09. The standard deviation of 0.594 suggests a relatively consistent positive perception of teacher engagement, with a minor degree of variability among participants. The scores range from a minimum of 1 to a maximum of 5.

Concerning "Teacher's professional development," participants, on average, rated the importance and effectiveness of professional development highly, with a mean of 4.30. The standard deviation of 0.649 indicates a moderate degree of variability in perceptions, and the scores range from a minimum of 1 to a maximum of 5, suggesting that while the majority values professional development, there are some variations in opinions.

It is observed that participants in the "Teacher's challenge" reported facing difficulties in STEM education, as indicated by a mean score of 4.07. The scores, ranging from 1 to 5, reflect diverse experiences and opinions regarding the challenges encountered during implementation. The relatively high standard deviation of 0.725 highlights significant variability in the reported challenges, suggesting that teachers' experiences with STEM education difficulties vary considerably.

Table 10 shows that the link between the independent variables (teacher perceptions) and the dependent variable (STEM PBL on 21st century skills) was tested using both simple and multiple linear regression. Based on correlation, the regression analyzes if there is a meaningful relationship and how much the components account for the dependent variable. When comparing the alpha error to the p-value, it is 5%.

The first Hypothesis (H1) explores the relationship between teachers' instructional integration (TII) and STEM Project-Based Learning (PBL) on 21st century skills. With an R-Square of 0.069, TII explains 6.9% of the variability in STEM. The F-Fisher's test, with $F(1,114) = 8.47$, rejects the null hypothesis that suggests no relationship between TII and STEM PBL on 21st century skills, indicating a significant association. A notable negative correlation is observed, implying that for every one-point increase in TII, STEM decreases by 0.345 ($P\text{-value} = 0.004 < 0.001$). This suggests that, despite educators' efforts in planning and belief in the benefits of STEM PBL, a higher focus on instructional integration might counterproductively impact the effectiveness of STEM PBL in fostering skills needed for the 21st century. The relationship between how teachers integrate instruction and the success of STEM PBL involves complexities.

Table 10 presents the analysis of Hypothesis (H2), exploring the relationship between teacher's engagement and STEM Project-Based Learning (PBL) on 21st century skills. The R-Square of 0.085 indicates that 8.5% of the variation in STEM is explained by teacher's engagement. The F-Fisher value of 10.6 ($F(1,114)$) rejects the null hypothesis which posits no significant relationship between teacher's engagement and STEM PBL, indicating a significant positive relationship between teacher's engagement and STEM PBL ($P\text{-value}=0.001<0.05$). The coefficient beta of 0.298 signifies that when teacher's engagement increases by one score, STEM scores increase by 0.298. Thus, the findings suggest that teacher's engagement has a meaningful and positive impact on the effectiveness of STEM PBL in promoting 21st century skills.

The third Hypothesis (H3) explores the relationship between teacher's challenge and STEM Project-Based Learning (PBL) on 21st century skills. The R-Square of 0.009 suggests that only 0.9% of the variability in STEM is explained by the teacher's challenge. The null hypothesis, which proposes no significant relationship between the teacher's challenge and STEM PBL, is not rejected as indicated by F-Fisher ($F(1,114) = 1.08$; $P\text{-value}=0.299>0.05$). This means that the teacher's challenge does not have a statistically significant impact on the effectiveness of STEM PBL in fostering 21st century skills, as per the results of the statistical analysis.

Hypothesis 4 (H4) explores the relationship between teachers' professional development and STEM PBL on 21st century abilities. The analysis in Table 10 reveals an R-Square of 0.128, indicating that 12.8% of the variability in STEM is explained by teachers' professional development. In line with the hypothesis, the null hypothesis, suggesting no association between TPD and STEM PBL, is rejected. The F-Fisher value of $F(1,114) = 16.7$ reveals a

significant relation between the two variables. The coefficient indicator demonstrates that for every one-point increase in teacher professional development, STEM increases by 0.334, with a highly significant p-value (<0.0001). The analysis in Table 10 firmly supports the hypothesis by providing evidence of a substantial and positive connection between teachers' professional development and the effectiveness of STEM PBL in fostering 21st century skills.

The final hypothesis, using multiple regression with all independent variables, highlighted that only teacher professional development had a significant positive impact on STEM ($R\text{-square}=0.147$), accounting for 14.7% of the variability. We rejected the null hypothesis, which suggests no relationship between the independent variables and the dependent variable, as the F-Fisher value ($F(4,111) = 4.798$) showed a significant association between the variables. Specifically, the coefficient beta for teacher professional development (TPD) indicated that STEM increases by 0.225 with a one-point increase in teacher professional development, emphasizing its meaningful role in influencing STEM outcomes. The multiple regression analysis reveals a significant positive relationship, suggesting that improvements in teachers' professional development are associated with increased STEM proficiency.

Table 10

Linear Regression Analysis of Independent Variables on STEM Project-Based Learning and 21st Century Skills

Hypothesis	Independent Variable	Dependent variable	R-Square	F-Fisher	Coefficient Beta	P-value
H1	Teachers' Instructional Integration	STEM PBL on 21 st	0.069	8.47*	-0.345	0.004**

	(TII)	Century Skills.				
H2	Teacher's engagement (TE)	STEM PBL on 21 st Century Skills.	0.085	10.6*	0.298	0.001**
H3	Teacher's challenge (TC)	STEM PBL on 21 st Century Skills.	0.009	1.08	0.081	0.299
H4	Teacher's professional development (TPD)	STEM PBL on 21 st Century Skills.	0.128	16.7*	0.334	<0.0001**
H5	TII, TE, TC, TPD	STEM PBL on 21 st Century Skills.	0.147	4.798*	0.225 (TPD)	0.045**

****<0.05; *<0.05**

4.4 Results Related to Question 2

How do the demographic differences among educators in Ajman schools impact their perspectives on the effectiveness of STEM project-based learning in fostering 21st century skills?

The data related to question 2 was analyzed using the Independent T-test and One-way ANOVA, supplemented by hypothesis testing through regression analysis, all performed on a sample of 116 respondents.

An independent T-test was applied to investigate whether there is a difference in the mean scores between female and male participants in the context of implementing STEM PBL and its influence on 21st century skills. Simultaneously, a One-Way ANOVA was conducted to examine variations in STEM PBL scores across other demographic variables, specifically those with three or more categories.

Table 11 shows there is no statistically significant difference in the mean scores of STEM between gender. The obtained P-value for gender in the analysis is 0.326. The alternative hypothesis (H1) suggests that there is a significant impact of gender on STEM project-based learning (PBL) concerning 21st century skills. On the contrary, the null hypothesis (H0) argues that there is no significant difference in mean scores between genders in STEM PBL. The findings indicate that gender does not have a noticeable effect on proficiency in STEM skills relevant to the 21st century. This conclusion is drawn from the absence of a significant difference in mean STEM scores between genders (P-value=0.326>0.05), preventing the rejection of the null hypothesis.

Table 11 reveals that there is no statistically significant difference in the mean scores of STEM between teaching experience. The P-value associated with teaching experience is 0.088, leading to the non-rejection of the null hypothesis (H0), which postulates no significant influence on mean STEM scores based on teaching experience. Conversely, the alternative hypothesis (H1) suggests a substantial impact of teaching experience on STEM project-based learning (PBL) in relation to 21st century skills. The data indicate that teaching experience may not have a statistically significant effect on STEM PBL, supported by the lack of notable variation in mean STEM scores across different teaching experiences (P-value=0.088>0.05). A closer look at the mean and standard deviation reveals slight differences in various teaching

experience categories: 1–5 years (Mean=4.07, SD=0.750), 6–10 years (Mean=4.12, SD=0.715), 11–15 years (Mean=4.40, SD=0.503), and more than 15 years (Mean=4.36, SD=0.435). Although there are variations in mean scores, the P-value suggests that these differences are not statistically significant.

There is no statistically significant difference in the mean scores of STEM across academic qualifications as shown in Table 10. The P-value for academic qualification is 0.443. Particularly, among different academic qualifications, "Master" has the highest mean STEM score (4.36) and the lowest standard deviation (0.486). However, the analysis does not find a significant difference in mean STEM scores based on academic background. The null hypothesis (H0) suggesting no considerable difference is not rejected, contrary to the alternative hypothesis (H1) proposing an impact of academic qualification on STEM project-based learning (PBL) and 21st century skills. The results indicate that the academic qualifications may not have a statistically significant on STEM PBL supported by the lack of evidence to support the idea that academic background significantly influences STEM PBL on 21st century skills (P-value=0.443>0.05).

The investigation outcomes in Table 11 indicate that individuals over 30 show the highest mean STEM score (4.36), and those under 25 have the lowest standard deviation (0.245). Despite these observed differences, statistical tests reveal that there is no significant variation in mean STEM scores based on age. Contrary to the alternative hypothesis (H1) proposing a significant impact of age on STEM project-based learning linked to 21st-century skills, the null hypothesis (H0) suggesting no substantial difference cannot be dismissed. The P-values associated with age groups (P-value=0.086>0.05) imply insufficient evidence to

support the idea that age significantly influences STEM PBL in a meaningful way according to the analysis.

Statistical testing as shown in Table 11 suggests that the mean STEM results are not significantly impacted by the academic major selected. In contrast, the alternative hypothesis (H1) suggests that the major has a significant impact on STEM project-based learning connected to 21st century abilities, rejecting the null hypothesis (H0), which suggests no meaningful difference. With P-values for major groups ($P\text{-value}=0.458>0.05$), the analysis suggests that there is not enough data to support the hypothesis that there is a substantial relationship between academic major and STEM project-based learning. The STEM mean scores and standard deviations for the various majors (ICT = 4.35, SD = 0.393, Math = 4.30, SD = 0.422, Science = 4.18, SD = 0.810) in this analysis do not exhibit significant differences that would be deemed statistically significant.

Finally, Table 11 reveals no noticeable difference, supporting the null hypothesis (H0) which suggests no significant difference, while the alternative hypothesis (H1) proposes a significant impact of grade level on STEM project-based learning for 21st century abilities. The results show a relation between grade level and STEM learning, as indicated by the P-values ($0.016<<0.05$). The data, illustrating mean STEM scores for each grade level in the table, offers evidence to support this theory. Particularly, high-grade respondents ($M=4.46$; $SD=0.458$) display better STEM proficiency compared to middle-grade respondents ($M=4.07$; $SD=0.637$). Tukey pairwise analysis shows no discernible differences between Elementary and Middle grades ($P\text{-value} > 0.05$) or between Elementary and High grades ($P\text{-value} > 0.05$).

Table 11

Mean, Standard Deviation ,T-Student, F-Fisher, and P-Value of the Demographic Variables

Demographic Variable	Category	N	Mean	St. Deviation	T-student F-Fisher	P-value
Gender	Female	88	4.28	0.670	T=0.988	0.326
	Male	28	4.19	0.330		
Teaching Experience	1-5 years	24	4.07	0.750	F=2.232	0.088
	6-10 years	26	4.12	0.715		
	11-15 years	33	4.40	0.503		
	More than 15 years	33	4.36	0.435		
Academic Qualifications	Bachelor	57	4.22	0.602	F=0.820	0.443
	Diploma	22	4.18	0.780		
	Master	37	4.36	0.486		
Grade level	Elementary	38	4.23	0.663	F=4.279 Tukey=0.38657; p=0.013	0.016*
	Middle*	37	4.07	0.637		
	High*	41	4.46	0.458		
Age	Less than 25 years	9	4.11	0.245	F=2.503	0.086
	25-30 years	27	4.06	0.660		
	More than 30 years	80	4.34	0.602		
Major	ICT	21	4.35	0.393	F=0.786	0.458
	Math	48	4.30	0.422		
	Science	47	4.18	0.810		

4.5 Results Related to Question 3 (The interview)

What practices do educators employ when implementing STEM project-based learning?

A semi-structured interview approach was utilized to gather insights on educators' perceptions and practices regarding STEM Project-Based Learning (PBL) and its impact on 21st century

skills.". The participants in the interviews included two male science leaders, one male ICT leader, and one female math leader. The teachers were posed with 7 questions that required "yes" or "no" responses, and they were also prompted to provide justifications for their answers. The outcomes of these interviews yielded the following results.

1. Are you familiar with STEM project-based learning?

All the teachers, that's 100% of them, said yes during the interview. They explained that they know about STEM Project-Based Learning and see it as an innovative way to blend science, technology, engineering, and math for a richer learning experience. One participant specifically noted the school's investment in creating a high-end STEM lab and incorporating STEM into the curriculum for grades 9 and 10 as contributing factors to their positive response. Another teacher said they can use what they learn to explore ideas and connect them to the real world in the classroom.

2. Have you experienced advantages as a teacher through the implementation of STEM project-based learning?

The four teachers who participated in the interview consistently responded with a "yes" to implementing STEM project-based learning. One leader explained that STEM Project-Based Learning allows students to apply their skills to bring ideas to life, building models to solve real-life problems. The main advantage is that students take ownership of their work and use interdisciplinary skills to achieve their goals. Two other leaders highlighted the usefulness of STEM PBL in boosting students' creativity, collaboration, critical thinking skills, and problem-solving skills, creating a dynamic and interactive classroom environment. The last leader mentioned that it provides a more realistic understanding of the concept.

3. Have students demonstrated learning behaviors, including communication, collaboration, problem solving, and creativity, during their active participation in STEM project-based learning?

All the 4 teachers, constituting 100% of the respondents, agreed that students showed good learning behaviors like talking with each other, working together, solving problems, and being creative during STEM project-based learning. The first teacher mentioned that some students wrongly think STEM is only for really smart kids, but even those who aren't top achievers in their school did well and showed skills in talking, working together, and thinking critically, especially when designing things like F1 cars. The second teacher saw improvements in how students learn, with better communication, teamwork, and problem-solving during STEM projects. The third teacher said students learn important skills like thinking systematically and solving problems when they do STEM activities.

4. Have you noticed academic advancements in your students as a result of STEM project-based learning?

Three out of four teachers (75%) affirmed that they observed academic advancements in their students due to STEM project-based learning. One teacher considered it a natural outcome, while another acknowledged improvement in most students' learning, with only a few facing challenges. A third teacher stated witnessing significant academic progress, emphasizing that STEM project-based learning enhances understanding of core concepts and reinforces practical application, contributing to improved academic performance. On the other hand, the last teacher (25%) disagreed, citing a lack of data to support the claim as their reason.

5. Have you encountered difficulties while incorporating STEM project-based learning in the classroom?

Three out of four teachers (75%) acknowledged encountering difficulties while implementing STEM project-based learning in the classroom. The first teacher pointed out challenges related to depending on external suppliers for materials and the time-consuming process of building their STEM lab due to high costs. The second teacher recognized occasional challenges, such as managing diverse student groups and coordinating resources, but emphasized that the overall benefits of STEM project-based learning outweigh these difficulties, providing valuable learning experiences for both the teacher and students. The third teacher mentioned challenges including limited resources, inadequate space, time limitation and disruptions caused by class changes. In contrast, the last teacher (25%) expressed the belief that with the appropriate infrastructure, resources, time, and a suitable methodology, difficulties could be minimized or avoided.

6. Did you receive training to prepare you to teach in a STEM project-based learning environment?

Three out of four teachers (75%) responded with a "no" regarding receiving training to prepare for teaching in a STEM project-based learning environment, stating that they did not come across such training. However, the last teacher (25%) answered affirmatively, mentioning that they received KHDA training to ensure effective implementation of STEM project-based learning in their classroom. This training provided them with the necessary tools and strategies to create a stimulating and supportive learning environment.

7. Do you endorse the shift in the teacher's role from being an information provider to a facilitator of acquiring information?

All four teachers responded with a "yes" regarding endorsing the shift in the teacher's role from being an information provider to a facilitator of acquiring information. They

explained that to prepare students to be international-minded and global citizens, it is crucial for them not only to identify problems but also to take active roles in finding solutions. Other teachers emphasized the importance of fostering independence and critical thinking, stating that this shift empowers students to actively explore and discover knowledge. Additionally, teachers highlighted the unique talents of their students, expressing that this approach allows students to be more creative in their own distinctive ways.

Thematic analysis was used to systematically identify and examine recurrent themes in participant replies on STEM Project-Based Learning, offering a nuanced knowledge of the complex features and experiences related to STEMPBL implementation.

4.6 Results of Open-Ended Questions

1. How do you integrate STEM PBL concepts into your curriculum to enhance the development of 21st century skills among your students?

Table 12

Educator's Responses to Open-Ended Question(1)

Various Strategies for Integrating STEM PBL	Frequency	Percent Valid	Valid percent	Cumulative Percent
Embedding STEM PBL projects as part of regular lesson plans	34	15.8	15.8	15.8
Infusing real-world problem-solving scenarios into STEM lessons	69	32.1	32.1	47.9
Collaborating with colleagues to	67	31.2	31.2	79.1

integrate STEM concepts across subjects				
Aligning STEM PBL activities with curriculum objectives and standards	45	20.9	20.9	100.0
Total	215	100.0	100.0	

The participants' responses, organized in Table 12, reveal distinct preferences for various strategies related to STEM PBL integration. Notably, "Infusing real-world problem-solving scenarios into STEM lessons" emerged as the most favored approach, capturing the preference of 32.1% of the respondents. Following this, a considerable number of participants, 31.2%, favored the strategy of "Collaborating with colleagues to integrate STEM concepts across subjects". In contrast, "Aligning STEM PBL activities with curriculum objectives and standards" secured the preference of 20.9% of respondents. Lastly, "Embedding STEM PBL projects as part of regular lesson plans" was chosen by 15.8% of participants.

2. In what way do you, as a teacher, collaborate with your peers during STEM Project-Based Learning to foster the development of 21st century skills among your students?

Based on the results in Table 13, it is evident that the most favored strategy is "Collaborating with school leaders to integrate 21st century skills into the curriculum," with 34.5% of participants endorsing this approach. This underscores the perceived importance of leadership involvement in incorporating essential 21st century skills into the educational curriculum. Following closely, 27.7% of participants prefer the strategy of "Co-teaching STEM PBL projects with colleagues to enhance collaborative teaching approaches," emphasizing the

significance of collaborative teaching methods. "Participating in joint lesson planning sessions with fellow teachers" is chosen by 23.3% of respondents, indicating the value placed on collaborative lesson planning in the integration process. Additionally, 14.6% of participants advocate for "Advocating for the integration of STEM education in school policies with administrative support," highlighting the importance of policy advocacy with administrative backing for successful STEM integration.

Table 13

Educator's Responses to Open-Ended Question(2)

Various Collaborative Strategies for STEM PBL Engagement	Frequency	Percent Valid	Valid Percent	Cumulative Percent
Participating in joint lesson planning sessions with fellow teachers	48	23.3	23.3	23.3
Collaborating with school leaders to integrate 21 st century skills into the curriculum	71	34.5	34.5	57.8
Co-teaching STEM PBL projects with colleagues to enhance collaborative teaching approaches	57	27.7	27.7	85.4

Advocating for the integration of STEM education in school policies with administrative support	30	14.6	14.6	100.0
Total	206	100.0	100.0	

3.What kind of professional development opportunities do you feel would further enhance your ability to effectively implement STEM project-based learning for the development of 21st century skills?

Table 14

Educator's Responses to Open-Ended Question(3)

Professional Development	Frequency	Percent Valid	Valid percent	Cumulative Percent
Workshops	98	46.0	46.0	46.0
Online courses	34	16.0	16.0	62.0
Conferences	30	14.1	14.1	76.1
Guidance programs	51	23.9	23.9	100.0
Total	213	100.0	100.0	

The majority of participants, as indicated in Table 14, prefer the traditional approach of 'Workshops,' accounting for 46.0% of responses as their top choice for professional development in STEM PBL. Following this, 23.9% of respondents show substantial interest in "Guidance programs," indicating a preference for more personalized and ongoing professional development initiatives. Online learning through "Online courses" is the choice for 16.0% of participants, highlighting the recognition of the flexibility and accessibility offered by digital platforms. Lastly, "Conferences" are chosen by 14.1% of participants, indicating an

acknowledgment of the value of networking and exposure to the latest trends in STEM education through event participation.

4. What challenges do you commonly encounter when implementing STEM project-based learning to promote the development of 21st century skills?

The provided data in Table 15, sheds light on the challenges faced by participants in the context of STEM education. The most frequently mentioned challenge is "Time limitation," with 24.6% of participants identifying it. This suggests that a substantial portion of educators perceives time constraints as a significant obstacle. The second most common challenge is the "Heavy workload," noted by 20.3% of participants, highlighting the impact of a demanding workload on effective STEM implementation. "Lack of resources" and "Lack of teacher support" are also noteworthy challenges, each mentioned by 15.4% and 11.1% of participants, respectively, emphasizing resource constraints and the importance of supportive environments. "No pre-established curriculum plans," "Meeting lesson objectives," and "Other" challenges are also acknowledged, indicating a diverse set of obstacles educators encounter in STEM education.

Table 15

Educator's Responses to Open-Ended Question(4)

Challenges	Frequency	Percent Valid	Valid percent	Cumulative Percent
Lack of resources	47	15.4	15.4	15.4
Heavy workload	62	20.3	20.3	35.7
Lack of teach support	34	11.1	11.1	46.9
Time limitation	75	24.6	24.6	71.5

No pre-established curriculum plans	33	10.8	10.8	82.3
Meeting lesson objectives	30	9.8	9.8	92.1
Other	24	7.9	7.9	100.0
Total	305	100.0	100.0	

Chapter 5: Discussion, Conclusion, Recommendations, and Limitations

This chapter critically reviews and discusses the research findings. Conclusions are drawn, recommendations are made and the chapter explores the study's limitations while suggesting possibilities for future research in the same field.

5.1 Discussion

This study is conducted to address three principal questions: firstly, to explore teachers' perspectives on the implementation of STEM project-based learning and its impact on enhancing 21st century skills in Ajman American-system schools in the UAE. Secondly, it seeks to investigate how differences in educators' demographics impact their perspectives regarding the effectiveness of STEM PBL in fostering 21st century skills. Thirdly, the study examines the practices educators employ when implementing STEM project-based learning. The initial questionnaire provides an overview of the current status of STEM PBL education in these schools, while more detailed insights are gathered through interviews and open-ended questions. As previously outlined in chapters three and four, the research follows a dual-phase approach, encompassing both quantitative and qualitative methods. The findings from this study exhibit alignment with those of previous research.

The quantitative analysis, particularly focusing on responses from the teachers' questionnaire, emphasized the positive impact of implementing STEM project-based learning on students' development of 21st century skills. Marked improvements were noted in teamwork and communication, enhanced creativity and problem-solving capabilities, innovative skills, and greater proficiency in technology use. These findings align with studies conducted by

Baran et al. (2021), Altan & Ercan (2016), and Shernoff et al. (2017). During the interviews in this study, 75% of respondents affirmed observing academic advancements in their students due to STEM project-based learning (Jarrar 2020). Furthermore, all leaders, constituting 100% of the respondents, agreed that students displayed positive learning behaviors, such as effective communication, collaboration, problem-solving, and creativity during STEM project-based learning. Chaya (2023) supports this viewpoint. The teachers displayed a thorough understanding of STEM education, seeing it as an instructional approach that permits the optional integration of knowledge across science, technology, engineering, and mathematics disciplines to craft a comprehensive STEM lesson.

In terms of teachers' views on integrating STEM project-based learning and its impact on 21st century skills, a range of responses and diverse implementation approaches were observed. The results emphasized that the majority of teachers place importance on closely linking STEM education with real-world applications, as indicated by 32.1% of responses in the open-ended questions. This perspective aligns with Drake's (1991) integration theory, advocating for a transdisciplinary approach that links STEM subjects to practical, real-life scenarios, aligning with the demands of the job market. This approach aims to equip students with creativity and critical thinking skills, promoting knowledge integration in engineering, science, and innovation (Chaya 2023). The predominant consensus, with 74.2% agreement, centered around the challenges arising from the lack of well-defined guidelines for successfully implementing the interdisciplinary approach. This emphasizes the importance of providing clear guidelines, as interdisciplinary STEM teaching practices contribute to cultivating advanced critical thinkers capable of addressing complex technological demands in today's world, as confirmed by Hamad et al. (2022). Additionally, 81.9% of teachers explained that STEM Project-Based

Learning is integrated into their lesson planning. These findings align with Hamad et al. (2022), highlighting the school's commitment to the successful practice of STEM by making it a requirement for teachers to include it in their lesson plans, with specific days and events allocated for working on STEM projects, such as the innovation week.

Regarding teachers' engagement in implementing STEM project-based learning for enhancing 21st century skills, survey results in this study reveal that 91.4% of teachers agree that collaborating with colleagues from various subjects enhances their teaching experience. Concerning the open-ended question, the favored approach, supported by 34.5% of participants, is "Engaging in collaboration with school leaders to incorporate 21st century skills into the curriculum." These findings align with Chaya's (2023) perspective, where the majority of teachers claim to frequently meet and collaborate with colleagues to plan and reflect on STEM activities. Margot and Kettler (2019) argue that teachers' collaborative planning is crucial for the successful implementation of STEM. Asghar et al. (2012) postulate that teachers' collaboration plays a significant role in STEM planning and implementation. However, challenges in collaboration are acknowledged, with 81.9% of teachers agreeing that working with teachers from different disciplines poses difficulties, particularly in terms of limited cooperation and coordination, with a mean score of 3.92. These findings align with Al Basha (2018), where teachers reported insufficient collaboration in schools, inadequate time for STEM activities, and challenges in implementing STEM initiatives. Interviews conducted in this study revealed that, despite expressing a desire for collaboration, teachers face difficulties such as time and resource limitations, and coordination among subjects. Some teachers even expressed a lack of collaboration in designing STEM activities and requested more opportunities for collaborative STEM sessions to overcome challenges and enhance

STEM implementation. A significant finding from the study is that 91.4% of teachers believe that engaging with STEM initiatives supported by the administration positively influences their teaching effectiveness in implementing 21st century skills. This contradicts Aldabbus's (2018) observation that some school administrations prefer simpler teaching methods, possibly to avoid disruptions, expenses, and adherence to the teaching plan provided by the Ministry of Education.

Regarding teachers' perceptions of professional development concerning the implementation of STEM project-based learning in fostering 21st century skills, a notable 94.9% strongly concurred that additional training in STEM PBL practices is crucial for improving students' outcomes, as highlighted in this study, with a mean rating of 4.28. Similarly, an equivalent percentage emphasized the necessity of training sessions on STEM-based contextual learning for teachers to enhance their technological skills. Forawi (2020) supports this, highlighting the importance of providing professional development for teachers to explore STEM as an integrative approach, focusing on student-centered and problem-solving techniques to meet the demands of 21st skills and motivate students in teaching and learning. In contrast, during the interviews in this study, 75% of teachers indicated receiving no training to prepare for teaching in STEM project-based learning. Regarding the responses to open-ended questions, Chaya's (2023) findings validate that a majority of teachers acknowledged receiving general support, including training and workshops, from their schools. However, they expressed a specific need for STEM-related professional development sessions to improve their understanding and application of STEM education. The majority of participants in this study favored the traditional approach of 'Workshops,' accounting for 46.0% of responses, as confirmed by Hamad et al. (2022), where particular selected teachers were

prepared to obtain certified degrees for subsequent training of other teachers within the same school. Al Basha (2018) also noted that 65% of teachers lack continuous training or professional development related to STEM.

Regarding teachers' challenges in implementing STEM project-based learning for enhancing 21st century skills, 90.5% of teachers, with a mean of 4.13, agree that they encounter challenges in this regard. Teachers point out that a lack of resources, including financial constraints and time limitations, hinders the adoption of new instructional approaches such as STEM project-based learning in enhancing 21st century skills. The main challenge, identified by 24.6% in response to open-ended questions, is time limitation. This aligns with studies conducted by Al Basha (2018), Altan & Ercan (2016), and Chaya (2023), all of which highlight challenges such as time and resource limitations, coordination among subjects, and financial shortages. Moreover, similar to the findings by Chaya (2023), the "constraint of time" reflects the results of Park et al. (2016), who suggested that the workload associated with STEM practices within busy school schedules requires extensive time and hinders effective STEM implementation. Elementary teachers share similar perceptions of challenges and difficulties in implementing STEM, such as a shortage of resources, innovative ideas, time constraints, the need for training, a lack of pedagogical knowledge, and the necessity for more collaboration among colleagues, as well as a deficiency in quality and flexible curriculum. Additionally, 88.8% of teachers find implementing new ideas challenging due to the demands, workload, and tasks associated with teaching, including assessments and examinations. This difficulty is supported by Chaya (2023), who highlights the need for guidelines provided by educational administrators and the lack of resources, coupled with additional teaching demands from academic administrators. However, 79.3% of teachers also find it challenging to incorporate

STEM Project-Based Learning because the curriculum lacks a built-in framework for this approach, this perspective is supported by Aldabbus's (2018) observation that the curriculum is artificial and lacks authenticity.

From the outcomes, it can be inferred that participants overwhelmingly agreed that each of the 18 items included in the questionnaire, interview questions, and open-ended inquiries substantially influences the implementation of "STEM PBL on 21st century skills.

In response to the second question, a thorough statistical analysis utilizing a one-way ANOVA test was performed to investigate the impact of educators' demographic differences on their perspectives regarding the effectiveness of STEM PBL in fostering 21st century skills. The results indicated that there is no significant difference in the mean scores of STEM PBL based on gender. This implies that, according to the collected data, educators' perceptions of STEM PBL effectiveness remain consistent regardless of gender. Similarly, no notable variation was observed in the mean scores of STEM PBL concerning teaching experience, suggesting that educators, irrespective of their tenure, share similar views on the efficacy of STEM PBL. This study provides a contrasting perspective to previous research. According to Park et al. (2016), they found that new teachers and female educators usually saw STEM education in a less positive way compared to experienced teachers and males. On the contrary, the rise in female students in science and mathematics, coupled with changing gender roles, may influence women's career choices in STEM fields, impacting their success. However, while gender appears to play a significant role in affective dimensions and 21st century skills, there is no distinct advantage for female students in cognitive and sociocultural skills (Atabey & Topcu, 2020). The analysis extended to academic qualifications, revealing no significant difference in mean STEM PBL scores, indicating a consistent perception among educators with

diverse academic backgrounds. Examining age groups, individuals over 30 exhibited the highest mean STEM PBL score at 4.36, with those under 25 displaying the lowest standard deviation at 0.245.

Despite these observed differences, statistical tests revealed no significant variation in mean STEM PBL scores based on age, emphasizing the limited impact of age on educators' perceptions. Additionally, the analysis explored the influence of academic major, determining that it does not significantly impact mean STEM PBL scores. The study's results affirm this conclusion, revealing that there is no significant distinction in the appreciation and utilization of project-based learning (PBL) across diverse academic majors, academic positions, and levels of teaching experience (Alrajeh, 2020).

In essence, the statistical analysis suggests a uniformity in educators' perceptions of STEM PBL effectiveness across various demographic factors. The findings revealed a significant influence of the grade levels taught on overall STEM PBL perception and implementation, as indicated by a P-value of 0.016 (which is less than the significance level of 0.05). High-grade respondents ($M=4.46$; $SD=0.458$) demonstrated a higher proficiency in STEM PBL compared to middle-grade respondents. This influence extended across multiple dimensions, encompassing teacher instructional integration, teacher engagement, teacher professional development, and teacher challenges. These factors collectively shape and impact educators' perspectives on the effectiveness of STEM project-based learning in nurturing 21st century skills. These outcomes align with the findings reported by Al Basha (2018). Notably, there were no significant differences observed between Elementary and Middle grades ($P\text{-value} > 0.05$) or between Elementary and High grades ($P\text{-value} > 0.05$). The results highlight that secondary school teachers exhibited more positive and proficient perceptions and

implementation of STEM PBL education compared to middle school teachers, with elementary teachers surpassing middle school counterparts. This was confirmed by Park et al. (2016) as they revealed that elementary school teachers were the most frequent users of STEAM education in their classrooms, followed by middle and high school teachers.

5.2 Conclusion

This study examined educators' perceptions and demographic impacts on implementing STEM project-based learning (PBL) for teaching 21st century skills. The outcomes, verified by open-ended questions and interviews, indicate that teachers possess well-informed views on STEM PBL. The insights shared by teachers indicate that all students derive academic advantages from STEM project-based learning (PBL), showcasing improved skills such as communication, collaboration, problem-solving, creativity, and proficiency in technology.

While teachers recognize the positive aspects of STEM project-based learning (PBL), they grapple with challenges when implementing it. Educators collectively agree on the positive influence of STEM PBL for teaching 21st century skills, emphasizing the necessity for professional development and a shift from traditional to facilitatory teaching approaches. Collaborative efforts with school leaders and administrative support positively impact teaching practices. Furthermore, collaborating with teachers from diverse disciplines is acknowledged as a challenging aspect, yet it is perceived to contribute to the improvement of teaching practices. High engagement, despite challenges, is viewed as advantageous. Integrating STEM PBL into the curriculum is noted to enhance 21st century skills by infusing real-world problem-solving scenarios into STEM lessons. Engaging students in STEM project-based learning equips them not only with marketable skills but also with the ability to effectively

address real-world challenges. The study notably underscores the grade level as a crucial factor, with high school teachers demonstrating superior proficiency in STEM PBL compared to their elementary and middle school counterparts. Nevertheless, no significant variations were observed based on qualifications, teaching experience, major, gender, or age. The study recommends further exploration through additional research.

5.3 Recommendations

STEM education is of paramount importance in contemporary learning environments, not only for academic subjects but also for nurturing 21st century skills. The ongoing evolution of STEM education underscores the necessity for effective strategies, such as project-based learning (PBL). This form of education is increasingly recognized for its role in shaping well-rounded individuals equipped with the abilities demanded in today's dynamic world. Discussions on the integration of STEM into educational practices consistently emphasize its positive impact on fostering essential 21st century skills, with existing literature reinforcing the consensus that the benefits far outweigh potential drawbacks.

However, the research revealed challenges hindering the effective implementation of STEM PBL. Teachers' proficiency in STEM instruction significantly influences students' learning outcomes, emphasizing the need for well-perceived pedagogical content and practical workshops. Time management emerges as a critical skill for teachers to master in succeeding with STEM PBL, especially considering the overwhelming planning involved. Clear guidelines and a specialized curriculum are essential for STEM PBL implementation, along with increased collaborative efforts among teachers facilitated by supportive administrators and school leaders.

To expand the study's scope, involving various academic institutions and schools across the UAE could provide valuable insights into the implementation of STEM PBL and its impact on developing 21st century skills. Enhancing the findings' robustness through direct observations of STEM PBL classrooms and additional instruments like student surveys or interviews would offer a more comprehensive understanding of STEM PBL's influence on skill development.

Further exploration, including semi-structured interviews with teachers and leaders, is recommended for future studies to delve deeply into participants' perspectives and provide detailed accounts of STEM PBL activities. The emphasis in this study was on teachers' perspectives, yet there is ample room for future research to conduct a comprehensive analysis involving various stakeholders, such as principals, parents, and students. In light of the research findings on the pivotal role of STEM education and the challenges in STEM PBL implementation, it is recommended that educational policymakers formulate supportive policies emphasizing clear guidelines, specialized curriculum, and collaborative initiatives. This approach aims to enhance teacher proficiency and address the identified challenges, ultimately fostering the development of 21st century skills in students.

5.4 Limitations

This study has its limitations, but these can be viewed as opportunities for future research by other scholars. Enhancing and expanding the sample size in the questionnaire would contribute to the study's robustness. Since the research was conducted in only three schools in Ajman, extending its scope to include other emirates in the UAE would yield a more comprehensive perspective. Additionally, the study's interviews included only four leaders,

with representation from one leader each in the disciplines of ICT and math, and two from science. According to (Smith, 2019), qualitative study findings may lack generalizability, and the results of this research are not generalizable. They represent the unique opinions and perspectives of the specific participants involved. A more diverse group of leaders from various disciplines would provide a more holistic understanding. The study also had a higher proportion of female participants compared to male participants. The primary hurdles are associated with time and resource limitations, which include managing workload and adapting to new instructional methods.

References

- Admawati, H., Jumadi, J., & Nursyahidah, F. (2018). The Effect of STEM Project-Based Learning on Students ' Scientific Attitude based on Social Constructivism Theory. In *Mathematics, Informatics, Science, and Education International Conference, (MISEIC 2018)*, (pp. 270-273). <https://doi.org/10.2991/miseic-18.2018.65>
- Agudelo & Vasco. (2019). *Project-Based Learning as a catalyst for Students and Teacher Autonomy Development : The experience in a State School in Nilo , Cundinamarca . 1*. 19(19), 31–48. <https://latinjournal.org/index.php/gist/article/download/699/610>
- Aldabbus, S. (2018). *PROJECT-BASED LEARNING : IMPLEMENTATION & CHALLENGES*. October. <https://www.researchgate.net/profile/Shaban-Aldabbus/project/BTC-candidate-teachers-opinion-of-projectbased-learning/attachment/5b8d7e7e3843b0067537935f/AS:666844868403200@1535999614238/download/Project-Based-Learning-Implementation-Challenges.pdf>
- Allen, M. S., Robson, D. A., & Iliescu, D. (2023). *A Critical but Ignored Component of Scale Construction in Psychological Assessment*. 39, 153–156.
- Alrajeh. (2020). The value and use of project-based learning in teacher preparation programs. *Cypriot Journal of Educational Sciences*, 15(5), 989–1010. <https://doi.org/10.18844/CJES.V15I5.5135>
- Atabey & Topcu. (2020). The Relationship between Turkish Middle School Students' 21st Century Skills and STEM Career Interest: Gender Effect. *Journal of Education in Science, Environment and Health*. <https://doi.org/10.21891/jeseh.739586>
- Ayu, P., Pradnyani, L., & Giri, N. (2021). *Teachers ' Perception of HOTS-Based Learning in*

EFL Classroom. 2(2), 103–108. <https://doi.org/10.36663/tatefl.v2i2.122>

- Aziz, E. (2015). Egyptian STEAM International Partnerships for Sustainable Development. *Ternational Journal for Cross-Disciplinary Subjects in Education (IJCDSE)*, 5(4), 2656–2660. <http://infonomics-society.org/wp-content/uploads/ijcdse/published-papers/special-issue-volume-5-2015/Egyptian-STEAM-International-Partnerships-for-Sustainable-Development.pdf>
- Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The Influence of Project-Based STEM (PjBL-STEM) Applications on the Development of 21st-Century Skills. *Journal of Turkish Science Education*, 18(4), 798–815. <https://doi.org/10.36681/tused.2021.104>
- Belbase, S., Mainali, B. R., Kasemsukpipat, W., Gochoo, M., Jarrah, A., & Group, F. (2022). At the dawn of science, technology, engineering, arts, and mathematics (STEAM) education: prospects, priorities, processes, and problems. *International Journal of Mathematical Education in Science and Technology* ISSN: <https://doi.org/10.1080/0020739X.2021.1922943>
- Brundiers, K., & Wiek, A. (2013). *Do We Teach What We Preach An International Comparison of Problem- and Project-Based Learning Courses in Sustainability*. 1725–1746. <https://doi.org/10.3390/su5041725>
- Bush, & B. (2019). *Education* (M. S. Khine & S. Areepattamannil (eds.)). Springer Nature Switzerland AG 2019. <https://doi.org/https://doi.org/10.1007/978-3-030-04003-1> Library
- Capraro, R. M., Capraro, M. M., Morgan, J. R. (2013). STEM Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach. In *STEM Project-Based Learning*. Sense Publishers. https://doi.org/10.1007/978-94-6209-143-6_7

- Capraro, R. M. (2017). No Title. *Electronic International Journal of Education, Arts, and Science*, 2, 140–158. <http://www.eij eas.com/index.php/EIJEAS/article/viewFile/110/108>
- Chaya, H. (2023). Investigating Teachers' Perceptions of STEM Education in Private Elementary Schools in Abu Dhabi. *Journal of Education and Learning*, 12(2), 60. <https://doi.org/10.5539/jel.v12n2p60>
- Cheng, M. M. H. (2022). An Overview of STEM Education in Asia. In *An Overview of STEM Education in Asia*. Springer Nature Singapore. <https://doi.org/10.1007/978-981-19-2596-2>
- Creswell, J. W. (2017). EDITION. *SAGE Publications India Pvt. Ltd, third edit*. <http://www.ceil-conicet.gov.ar/wp-content/uploads/2015/10/Creswell-Cap-10.pdf>
- Eltanahy & Forawi. (2019). Science Teachers' and Students' Perceptions of the Implementation of Inquiry-Based Learning Instruction in a Middle School in Dubai. *Journal of Education*, 199(1), 13–23. <https://doi.org/10.1177/0022057419835791>
- Eltanahy & Forawi. (2020). STEM leaders and teachers views of integrating entrepreneurial practices into STEM education in high school in the United Arab Emirates. *Entrepreneurship Education*, 3(2), 133–149. <https://doi.org/10.1007/s41959-020-00027-3>
- Fouad. (2018). *The impact of STEM project-based learning on the achievement of high school students in UAE (science , technology , engineering , and mathematics)* ايلعلا قلحرملا يف / قبلطلا عادأ روطت بلع قجنانلا راث لا / يصقتل قسارد) ميتس ققيرطب بيسردم عورشم لمع دعب تارا / December. <https://doi.org/2016101075>
- Haddad, T. N. (2022). *Project-Based Learning: Teachers' Perceptions*. <https://digitalcommons.acu.edu/cgi/viewcontent.cgi?article=1544&context=etd>
- Hamad, S., Tairab, H., Wardat, Y., Rabbani, L., Alarabi, K., Yousif, M., Abu-Al-Aish, A., &

- Stoica, G. (2022). Understanding Science Teachers' Implementations of Integrated STEM: Teacher Perceptions and Practice. *Sustainability (Switzerland)*, 14(6), 1–19. <https://doi.org/10.3390/su14063594>
- Jarrar, H. (2020). Impact of Implementing STEM PBL Approach on Elementary Students' Science Academic Achievement in Sharjah [British University]. In *Doctoral dissertation, The British University in Dubai (BUID)* (Issue January). <https://doi.org/20172705>
- Kang, N. (2019). A review of the effect of integrated STEM or STEAM (science , technology , engineering , arts , and mathematics) education in South Korea. <https://link.springer.com/content/pdf/10.1186/s41029-019-0034-y.pdf>
- Kant, J. M., Burckhard, S. R., & Meyers, R. T. (2018). *Engaging High School Girls in Native American Culturally Responsive STEAM Enrichment Activities*. January, 15–25.
- Kelley, T. R., Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3, 1–11. <https://doi.org/10.1186/s40594-016-0046-z>
- Macmath, S., Sivia, A., & Britton, V. (2017). *Teacher Perceptions of Project Based Learning in the Secondary Classroom*. 63, 175–192. <https://journalhosting.ucalgary.ca/index.php/ajer/article/view/56345>
- Madani, R. (2021). Reforming GCC mathematics and science curricula. *ICSIT 2021 - 12th International Conference on Society and Information Technologies, Proceedings, June*, 137–142. https://www.researchgate.net/publication/352399846_Reforming_GCC_Mathematics_and_Science_Curricula
- Margot, A., & Kettler. (2019). *Teachers ' perception of STEM integration and education : a*

systematic literature review. 2. <https://files.eric.ed.gov/fulltext/EJ1178347.pdf>

- Mirza, H., Bellalem, F., & Mirza, C. (2023). Ethical Considerations in Qualitative Research : Summary Guidelines for Ethical Considerations in Qualitative Research : Summary Guidelines for Novice Social Science Researchers. *Social Studies and Research Journal*, May. https://www.researchgate.net/profile/Fouzi-Bellalem/publication/370838199_Ethical_Considerations_in_Qualitative_Research_Summary_Guidelines_for_Novice_Social_Science_Researchers/links/646545267020266316541da5/Ethical-Considerations-in-Qualitative-Research
- Murshidi, G. Al. (2019). STEM education in the United Arab Emirates: Challenges and possibilities. *International Journal of Learning, Teaching and Educational Research*, 18(12), 316–332. <https://doi.org/10.26803/ijlter.18.12.18>
- Pablo Aránguiz, Palau-Salvador, and and J. P. (2020). *Critical Thinking Using Project-Based Learning : The Case of The Agroecological Market at the “ Universitat Polit ècnica de Val ència .”* <https://www.mdpi.com/2071-1050/12/9/3553/pdf>
- PAN, SEOW, A. K. (2019). *Institutional Knowledge at Singapore Management University Examining learning transformation in project-based learning process Examining Learning Transformation in Project-based Learning Process*. 167–180. https://ink.library.smu.edu.sg/cgi/viewcontent.cgi?article=2815&context=soa_research
- Papert, S., Harel, I. (1991). Situating Constructionism. In *Seymour Papert and Idit Harel’s book Constrcutionism* (Vol. 36, Issue 2). <https://pirun.ku.ac.th/~btun/papert/sitcons.pdf>
- Park et al. (2016). Teachers ’ Perceptions and Practices of STEAM Education in South Korea. *Eurasia Journal of Mathematics, Science & Technology Education*, 12(7), 1739–1753. <https://doi.org/10.12973/eurasia.2016.1531a>

- Parmin, & Sajidan. (2019). The application of STEM education in science learning at schools in industrial areas. *Journal of Turkish Science Education*, 16(2), 278–289. <https://doi.org/10.12973/tused.10281a>
- Petersen, C. (2020). *Project-Based Learning through the Eyes of Teachers and Students in Adult ESL Classrooms* 3URMHFW % DVHG / HDUQLQJ WKURXJK WKH (\ HV RI 7HDFKHUV DQG 6WXGHQWV LQ \$ GXOW. February 2016. <https://doi.org/10.3138/cmlr.2096>
- Rahman, Z. A. (2020). *PROCEEDINGS OF NARATHIWAT INTERNATIONAL CONFERENCE (NIC ' 19) “ Effective Educational Culture Through Research Practice ”* (Issue November 2019). https://www.researchgate.net/profile/Ahmad-Mat-Yusoff/publication/342352957_PROCEEDINGS_OF_NARATHIWAT_INTERNATIO_NAL_CONFERENCE_NIC'19_Effective_Educational_Culture_Through_Research_Pra ctice/links/5ef02a3e92851ce9e7fae153/PROCEEDINGS-OF-NARATHIWAT-INTERNAT
- Roebianto, A., Al, U., Indonesia, A., Savitri, I., Buana, U. M., Syaiful, I. A., & Buana, U. M. (2023). *CONTENT VALIDITY: DEFINITION AND PROCEDURE OF CONTENT VALIDATION*. March. <https://doi.org/10.4473/TPM30.1.1>
- Smith, B. (2019). Generalizability in qualitative research : misunderstandings , opportunities and recommendations for the sport and exercise. *Qualitative Research in Sport, Exercise and Health*, August, 1–13. <https://doi.org/10.1080/2159676X.2017.1393221>
- Srikoom, W., & Hanuscin, D. L. (2017). *Perceptions of in-service teachers toward teaching STEM in Thailand*. 18(2), 2017.
- Suleiman, Y. (2021). No Title. *Integrating Technopreneurship Education in Nigerian*

Universities Strategy for Decreasing Youth Unemployment, 11(1), 49–76.

<https://kusoed.edu.np/journal/index.php/je/article/view/501/216>

SURATNO, S., WAHONO, B., CHANG, C. Y., RETNOWATI, A., & YUSHARDI, Y. (2020).

Exploring a Direct Relationship between Students' Problem-Solving Abilities and Academic Achievement: A STEM Education at a Coffee Plantation Area. *Journal of Turkish Science Education*, 17(2), 211–224. <https://doi.org/10.36681/tused.2020.22>

Susanti. (2020). *Students ' Perception Toward the Implementation of Project Based Learning*

for EFL Vocational. 390(Icracos 2019), 115–119.

https://www.academia.edu/download/61678788/Tsybulsky_et_al._2020_EJTE20200104-65240-3xkeyf.pdf

Thi, N., Khuyen, T., Bien, N. Van, Lin, P., & Lin, J. (2020). *Measuring Teachers ' Perceptions*

to Sustain STEM Education Development. 1–15. <https://www.mdpi.com/2071-1050/12/4/1531/pdf>

Thibaut, L., Ceuppens, S., Loof, H. De, Meester, J. De, Goovaerts, L., & Brussel, V. U. (2018).

Integrated STEM Education : A Systematic Review of Instructional Practices in Secondary Education. *European Journal of STEM Education*, 3(1), 1–12. <https://files.eric.ed.gov/fulltext/EJ1178347.pdf>

Topçiu, D. M. and D. J. M. (2015). *Vygotsky Theory on Social Interaction and its Influence on*

the Development of Pre-School. 9563(August), 103–110. https://revistia.com/files/articles/ejser_v2_i3_15/Marta.pdf

Tunc & Bagceci. (2021). *Teachers ' Views of the Implementation of STEM Approach in*

Secondary Schools and The Effects on Students. 6(1), 1–11. <https://files.eric.ed.gov/fulltext/EJ1287243.pdf>

- UAE Government. (2018). *The National Air Quality Agenda 2031*. <https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/the-national-air-quality-agenda-2031>
- Viro, E. (2020). *Teach hers ' per rspective es on pro ning in m mathema tics and science s*. 8(1), 12–31. <https://doi.org/https://doi.org/10.30935/scimath/9544>
- Wan Husin et. al. (2021). *Fostering students ' 21st century skills through Project Oriented Problem Based Learning (POPBL) in integrated STEM education program*. June. https://www.researchgate.net/profile/Wan-Nor-Fadzilah-Wan-Husin/publication/349195017_Fostering_students'_21st_century_skills_through_Project_Oriented_Problem_Based_Learning_POPBL_in_integrated_STEM_education_program/links/60d91d9ea6fdccb745ecbf2b/Fosteri
- Warr and West. (2020). *Problem-based Learning Problem-based Learning Bridging Academic Disciplines with Interdisciplinary Project-based Learning : Challenges and Opportunities*. 14(1), 1–23. <https://scholarworks.iu.edu/journals/index.php/ijpbl/article/download/28590/35083>
- Wexler, A., & Largent, E. (2023). *Ethical considerations for researchers developing and testing minimal-risk devices*. 1–5. <https://doi.org/10.1038/s41467-023-38068-6>
- Wieselmann, Sager, & Price. (2022). STEM Project-Based Instruction: An Analysis of Teacher-Developed Integrated STEM PBI Curriculum Units. *Education Sciences*, 12(9), 0–21. <https://doi.org/10.3390/educsci12090626>
- Xie, Y., Fang, M., & Shauman, K. (2015). *STEM Education*. <https://doi.org/10.1146/annurev-soc-071312-145659>
- Zheng, Y., Xu, A., Zheng, Q., & Shieh, C. (2021). *The Practice of Project-Based Learning to*

Outdoor Ecological Education on the Promotion of Students ' Problem-Solving Capability. 3410.

Appendices

Appendix A

STEM Project Based Learning Teachers' Questionnaire

Instrument of the study:

Section 1: Demographic Information

a. Gender: Male ☐ Female ☐

b. Age:

- Less than 25 years ☐
- 25-30 years ☐
- More than 30 years ☐

c. Teaching Experience:

- 1-5 years ☐
- 6-10 years ☐
- 11-15 years ☐
- More than 15 years ☐

d. Academic Qualifications:

Bachelor ☐ Diploma ☐ Masters ☐

e. Grade level you instruct: Elementary ☐ Middle ☐ high ☐

f. Major Subject: Science ☐ Math ☐ ICT ☐

Section 2:

No	statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Impact of STEM PBL on 21st Century Skills						
1	Implementing STEM project-based learning in my teaching improves students' problem-solving skills.					
2	STEM project-based learning serves as a key factor in nurturing and enhancing students' critical thinking abilities.					
3	Applying STEM project -based learning in education is crucial for promoting collaboration among students.					
4	Applying STEM project -based learning in education is crucial for promoting communication among students.					
5	Applying STEM project-based learning, students can articulate a problem and actively seek innovative solutions.					
6	Incorporating technology plays a valuable role in promoting creativity in STEM project-based learning education.					
7	Incorporating technology during STEM project-based learning provides students with an interactive and innovative educational experience.					

Teachers' Instructional Integration						
8	There is a lack of well-defined guidelines for the successful implementation of the interdisciplinary approach (STEM PBL).					
9	Incorporating STEM Project-Based Learning (PBL) into my teaching practice is evident in my planning.					
10	Engaging students in STEM project-based learning equips them not only with marketable skills but also with the ability to effectively address real-world challenges.					
Teachers' Engagement						
11	Collaborating with teachers from different disciplines poses challenges, particularly in terms of limited cooperation and coordination.					
12	Collaborating with colleagues from diverse subjects enhances my teaching experience.					
13	Engaging with STEM initiatives, supported by the administration, positively influences my teaching effectiveness.					

Teachers' Professional Development						
14	I believe additional training in STEM PBL practices is essential to enhance students' outcomes.					
15	Professional training sessions on STEM-based contextual learning are necessary for teachers to improve their technological skills.					
Teachers' Challenges						
16	The lack of resources, both in terms of finances and time, poses a challenge for teachers in adopting new instructional approaches, including STEM project-based learning on 21 st century skills.					
17	Implementing new ideas is challenging for teachers due to the demands, workload, and tasks associated with teaching, including assessments and examinations.					
18	Teachers find it challenging to incorporate STEM Project-Based Learning (PBL) because the curriculum lacks a built-in framework for this approach.					

Appendix B

Open-ended Questions

Dear instructor, please answer the following questions:

1. Teacher' Instructional Integration:

How do you integrate STEM PBL concepts into your curriculum to enhance the development of 21st century skills among your students?

2. Teachers' Engagement:

In what ways do you engage students during STEM Project-Based Learning to foster the development of 21st century skills such as critical thinking and collaboration?

3. Teachers' Professional Development:

What kind of professional development opportunities do you feel would further enhance your ability to effectively implement STEM Project-Based Learning for the development of 21st century skills?

4. Teachers' Challenges:

What challenges do you commonly encounter when implementing STEM Project-Based Learning to promote the development of 21st century skills?

Appendix C

Interview questions

Dear teachers (have leaders' role as well), please answer the following questions.

No.	Statement	Yes	No	Why
1	Are you familiar with STEM project-based learning?			
2	Have you experienced advantages as a teacher through the implementation of STEM project-based learning?			
3	Have students demonstrated learning behaviors, including communication, collaboration, problem-solving, and creativity, during their active participation in STEM project-based learning?			
4	Have you noticed academic advancements in your students as a result of STEM project-based learning?			
5	Have you encountered difficulties while incorporating STEM project-based learning in the classroom?			
6	Did you receive training to prepare you to teach in a STEM project-based learning environment?			
7	Do you endorse the shift in the teacher's role from being an information provider to a facilitator of acquiring information?			

Appendix D

Teachers' consent form

Dear Teachers,

The following questionnaire was designed to gather data for a master's dissertation at the British University in Dubai. The study, titled "Investigating Educators' Perceptions of the Impact of STEM Project-Based Learning on 21st Century Skills", aims to explore how educators perceive the effectiveness of STEM project-based learning in advancing 21st century skills in UAE. The questionnaire includes statements related to the impact of STEMPBL on 21st century skills, teachers' instructional integration, teachers' engagement, teachers' professional development, and teachers' challenges. Please place a tick in front of each statement in the box that aligns with your perception of teaching science. Your responses are requested to be provided freely, as the information will be treated as confidential and used solely for research purposes.

Researcher

Sanaa Al-Timani

Master of education in Science Education

The British University in Dubai.

CONSENT FORM

☐ Teacher Name (Optional):

☐ School:

I agree to participate in the research being carried out by Ms. Sanaa Al-Timani at The British University in Dubai.

I do **NOT** agree to participate in the research being carried out by Ms. Sanaa Al-Timani at The British University in Dubai.

Signature(s) of the teacher:

Date:

PLEASE RETURN THIS FORM DIRECTLY TO THE RESEARCHER