Impact of Implementing STEM PBL Approach on Elementary Students' Science Academic Achievement in Sharjah

أثر تطبيق منهج STEM PBL على التحصيل العلمي للطلاب في المرحلة
الابتدائية في بالشارقة

by

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Dissertation submitted in fulfilment

of the requirements for the degree of

MASTER OF EDUCATION

at

The British University in Dubai

January 2020

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Abstract

Nowadays, STEM education is trendy due to high demand for its professions: Science, Technology, Engineering, and Mathematics. As the future is in need of improving students with a variety of required skills, many countries are improving their educational systems to meet such high demand. Project Based Learning (PBL), in the STEM education is considered as one of the best practices where the United Arab Emirates is paying a great deal of attention in order to improve the educational system. The current study was carried out in order to investigate the impact of implementing STEM PBL approach on elementary students' academic achievement in science classes in the UAE. In this study, the participants were from a school in Sharjah that adopts the American curriculum. This study followed the explanatory sequential mixed method approach with focus on quantitative approach. Pretest posttest quasi-experimental design were used to collect quantitative data were one hundred and twelve grade five boys were divided in to control group (57 students) and experimental group (55 students). The experimental group students were taught using STEM PBL approach for five weeks while the control group learned the same topic with Non-STEM PBL approaches. Data were collected using the energy transformation test (ETT) that was developed by the researcher as a pretest and posttest for both groups. Data collected from the test was analyzed using SPSS statistical package. Qualitative data was collected using semi-structured interviews that was carried out with many students from the experimental group after finishing the experiment in order to gain stronger and deeper interpretations that support the findings of the quasi-experiment. After analyzing the data, the results showed that STEM PBL approach has a positive impact on the academic achievement of elementary students in science where the scores mean in the posttest for the control and experimental groups were 6.07 and 7.38 respectively. The independent T-test results between the posttest scores for the experimental and control group was for t (110) = 4.142 with a P = 0.000 < 0.05 which indicate a statistically significant difference between both groups which means that STEM PBL approach enhanced the students' achievement in science. Moreover, the qualitative results indicated that STEM PBL approach had a positive effect on the students ' motivation, achievement and developing their 21st century skills. In addition, it is found that STEM PBL have an impact on increasing the interest of learners in future, STEM careers. Thus, to provide data that are more reliable it is advised to carry out this study with larger number of students from different schools that follows different curriculums from different levels. Moreover, the current study did not focus on the challenges that may face the implementation of STEM PBL approach, so it is recommended to carry out a research to study these challenges in addition to the role of admins in the implementation of STEM PBL.

Keywords: STEM education, Project-based learning.

الملخص

في الوقت الحاضر، يعد تعليم العلوم والتكنولوجيا والابتكار (STEM) عصريًا نظرًا للطلب الكبير على مهنها: العلوم والتكنولوجيا والهندسة والرياضيات. نظرًا لأن المستقبل بحاجة إلى تحسين الطلاب بمجموعة متنوعة من المهارات المطلوبة، فإن العديد من الدول تعمل على تحسين أنظمتها التعليمية. يعتبر التعليم القائم على المشاريع(PBL) ، في التعليمSTEM ، أحد أفضل الممارسات التي تولي فيها دولة الإمارات العربية المتحدة قدراً كبيراً من الاهتمام من أجل تحسين النظام التعليمي. وقد أجريت الدراسة الحالية من أجل التحقق في تأثير تطبيق نهج STEM PBL على التحصيل الدراسي للطلاب في المرحلة الابتدائية في فصول العلوم في دولة الإمارات العربية المتحدة. في هذه الدراسة، كان المشاركون من مدرسة في الشارقة تعتمد المنهج الأمريكي. اتبعت هذه الدراسة النهج المختلط المتسلسل مع التركيز على النهج الكمي. تم استخدام تصميم الاختبار التجريبي شبه التجريبي لجمع البيانات الكمية وتم تقسيم مائة واثني عشر طالبا من الصف الخامس الى مجموعة ضابطة (57 طالبا) والمجموعة التجريبية (55 طالبا). تم تدريس طلاب المجموعة التجريبية باستخدام نهج STEM PBL لمدة خمسة أسابيع في حين تعلمت المجموعة الضابطة نفس الموضوع مع النهج غير .STEM PBL تم جمع البيانات باستخدام اختبار تحويل الطاقة الذي تم تطويره من قبل الباحث باعتباره الاختبار القبلي والبعدي لكلا الفريقين .تم جمع البيانات النوعية باستخدام مقابلات شبه منظمة تم إجراؤها مع العديد من الطلاب من المجموعة التجريبية بعد الانتهاء من التجربة من أجل الحصول على تفسيرات أقوى وأعمق تدعم نتائج التجربة شبه. أظهرت النتائج أن نهج STEM PBL له تأثير إيجابي على التحصيل الأكاديمي للطلاب في العلوم حيث تعني الدرجات في الاختبار البعدي للمجموعات الضابطة والتجريبية 6.07 و7.38 على التوالي. كانت نتائج-T testالمستقلة بين درجات الاختبار البعدي للمجموعة التجريبية والتحكمية لـ $t\ (110) = 4.142$ مع $P = 0.000 < 0.05$ والتي تشير إلى وجود فروق ذات دلالة إحصائية بين المجموعتين مما يعني أن نهج STEM PBL عزز الطلاب الإنجاز في العلوم. علاوة على ذلك، أشارت النتائج النوعية إلى أن نهج STEM PBL له تأثير إيجابي على تحفيز الطلاب وإنجازهم وتطوير مهاراتهم في القرن الحادي والعشرين. بالإضافة إلى ذلك، وجد أن STEM PBL له تأثير على زيادة اهتمام المتعلمين بالمستقبل، وظائف .STEM وبالتالي، لتوفير بيانات أكثر موثوقية، يُنصح بإجراء هذه الدراسة مع عدد أكبر من الطلاب من مدارس مختلفة تتبع مناهج مختلفة من مستويات مختلفة. علاوة على ذلك، لم تركز الدراسة الحالية على التحديات التي قد تواجه تنفيذ نهج STEM PBL، لذلك يوصى بإجراء بحث لدراسة هذه التحديات بالإضافة إلى دور المسؤولين في تنفيذ STEM PBL.

الكلمات المفتاحية: تعليم STEM، التعلم القائم على المشاريع.

Dedication

Every challenge needs self-effort as well as the support of people who are very close to our hearts, so it would be hard to reach for this achievement without their support.

I would proudly like to share my gratitude to my dear parents, who always encouraged and inspired me to complete this research.

I would like to thank my supervisor, **Prof. Sufian A Forawi**, for his patience, inspiration and support.

Thanks to my friends and to everyone who expressed words of advice and support to complete this research.

Acknowledgement

First and foremost, praises to Almighty Allah for his blessings throughout my research work to complete the research successfully.

I would like to express my deep and sincere gratitude to my research supervisor, **Prof. Sufian A. Forawi** for giving me this opportunity to do this research and providing me with inevitable guidance throughout the research. His vision, sincerity and motivation have deeply inspired and motivated me.

I am extremely grateful to my friends and parents for their love, prayers and caring for educating and preparing me for my future.

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Chapter 1: Introduction

Nowadays, due to the new technologies, the world is developing rapidly in which new problems emerge. Such developments have built up high expectations and difficult contests and obstacles in the future. In fact, the multiple and accelerated development of technology require the new generation to be prepared and equipped with the expertise and skills needed to follow it up in the future. As a result, efforts are required to implement a new transformation in the education field as an integral part of society. The value of improving education has significantly increased these days (UAE Vision 2030). Essentially, teaching science, mathematics, engineering and technology in a manner that improves professional pedagogical content and interacts with real-life issues. It is much needed to cultivate a new generation that is empowered by strong thinking skills that can support their communities and bring up the economies of their countries (Radloff & Guzey, 2016). Although recognizing the importance of cultivating STEM pioneers, education is struggling to keep up with the growing demands of individuals in STEM careers (Yu, H.-P. and Jen, E, 2020). STEM skills (science, technology, engineering and mathematics) are attracting increasing global recognition, with these skills constantly in demand not only in particular STEM fields but also beyond them (Commonwealth of Australia, 2015; Education Council). STEM is a significant endorsement throughout the world, helping to inspire the academic outcomes of well-qualified graduates (McDonald, 2016). Globally, improvement in education is being directed by promoting pupils to study STEM subjects and majors as their future careers, countries need to follow the increasing need for workforce consequently sustaining the minimum level of engineer's educators and technicians (Wan Husin et al. 2016). The integration of STEM and project-based learning (PBL) has become an effective approach because it aims to meet the K-12 science education standards and next-generation science standards (NGSS) system (NSTA 2013). To develop a new competitive generation, promote educational process and equip the learners with the required skills such as problem-solving, critical thinking, collaboration, creativity, and communication, countries are embracing the STEM curriculum (Lou et al. 2017).

1.1 Background of the Research

Educational systems need to train a generation that can take on future obligations by preparing them to succeed in the rapidly changing world and to maintain strong competition among nations without the need for other countries ' resources. Moving from old teaching strategies to STEM PBL help to build a generation that is innovative and capable of solving problems (Wan Husin et al. 2016). In order to compete with other industrial countries further graduate students in STEM fields need to be promoted. STEM PBL approach has a great influence in the development of students learning and educational process where it will produce high-quality engineers and educators who are able to compete in global competition and fit into national and international vacancies and needs (Hathcock et al 2015; Craft and Capraro, 2017). STEM PBL relies on relations between the STEM disciplines in the real world. Moreover, PBL practices enable students to effectively address actual-world issues by communicating with others and asking questions to find an appropriate answer by problem solving, critical thinking and creative skills under the supervision and guidance of educators (Craft & Capraro 2017; Han 2017). Kunberger, T. (2013) illustrated that the use of PBL results in more fair students meeting or exceeding the goals of teachers than regular lecturing. Tseng et al (2013) suggest that student attitudes have changed dramatically in a PBL environment after the introduction of integrated technology, technology, engineering and mathematics. Students find STEM to be very helpful in everyday cases and supply more improvements to society and make the community more prosperous as it enhances productivity and careers for people. Students in the U.A.E. who were taught using STEM PBL approach had better progress because it helped to improve their 21st century skills such as communication, critical thinking and creativity as concluded by a study carried by El Sayary (2014).

Many researchers support provide students with opportunities to solve real life problems and think critically (Kennedy and Odell 2014). Students are therefore behaving as scientists, explorers and engineers; where these are at the core of the STEM education program. STEM PBL learning is an interdisciplinary approach in the same class; all disciplines are dealt with as a complex mass in which the substance of all disciplines is connected (Hansen & Gonzalez 2014). STEM approach on the other hand, could be implemented as a multidisciplinary approach in which each discipline is taught in different classes where the main disciplines are the center of a dilemma or task in conjunction with other disciplines (Asunda & Mativo 2016; Ritz & Fan 2015). It is critical for students to be able to develop STEM concepts in real-world applications where this can be accomplished by eliminating the boundaries between disciplines and implementing effective cross-disciplinary curricula (Asghar, et. al. 2012). In addition, in order to acquire effective STEM, several researchers called for the incorporation of science and mathematics principles in engineering and technology, it is important that science and math curricula require engineering and technology applications to promote and improve scientific inquiry and engineering design skills (Asunda & Mativo 2016; Kelley & Knowles 2016).

The main objective of the current education initiative is to draw students ' attention to learning by discussing their passions, increasing their desire to dig deeper into knowledge, as well as developing knowledge as real scientists. Write or paste something here, and then press Quill It. Through this reform, we will be able to develop a new generation of learners who are prepared with the suitable mindset to guide them in their development and give them an active role in developing their anticipation. STEM PBL approach implementation helps in enhancing students' critical thinking and reasoning (Kim et al. 2013).

1.2 Statement of the Problem

Education is the most precious component opening the doors of creativity; it is a fundamental element leading to the transformation of countries. For this reason, the majority of nations in the world call for a significant transformation of the teaching and learning system, which corresponds to the rapid social development of the 21st century. Therefore, these new teaching approaches will prepare learners to be influential members of their community and to have the required skills they need to face the real life.

STEM education went beyond individual disciplines and combine the disciplines in order to address real life problems and challenges for students in order to develop a design for a certain task (NRC, 2012). STEM education provides the best potential to increase learners ' awareness, creativity, critical thinking skills, and to be independent learners. STEM education is a broad field because it is connected with many sub-sections in every particular discipline, rendering STEM education interesting and challenging for the students (Winn, Mi Choi & Hand, 2016). One of the most important approaches applied in STEM schools has arisen from STEM PBL (Han, 2017). STEM education focuses on the economic challenges facing the world, especially in developing countries, as it responds to the creation of skilled persons equipped with the 21st century skills as concluded by Ritz and Fan (2015). To retain their interest in STEM subjects, students must partake in active learning activities on a regular basis. The potential reasons for declining interest in STEM subjects may be due to the quality of teaching and learning encountered in the classroom by students (Shahali et al, 2017). Efficient STEM education results from children's early desire to explore and experience the world surrounding them (National Research Council [NRC], 2011). Therefore, the root of STEM education goes back to early childhood (Moomaw, 2013). Each child is essentially an excited STEM implementer who strives to uncover and recreate the world around him. In fact, young learners are not only the first users of technology, but also by their nature armed with the essential features of STEM education; that is, enthusiasm, teamwork, critical thinking and imagination (Chesloff, 2013). In addition, most basic skills start in early childhood to learn STEM principles such as problem solving, mathematical understanding, scientific inquiry and critical thinking (Aldemir & Kermani, 2016). In contrast to better achievements, the cross-disciplinary curricula has a better influence on the comprehension of mathematics and scientific topics among students (Hasnsen and Gonzalez 2014). Through inquiry approaches and engineering design, STEM learning can foster problem solving (Kasza and Slater, 2017).

As a developing country, the rapid development of the economic sector in the UAE needs an emphasis on the new generation's quality of education which benefits students and the economy. The goal in the UAE is a well-established and deepening to prepare a skilled STEM generation. Accordingly, several institutions, such as the Knowledge and Human Development Authority (KHDA) in Dubai, are collaborating with the M.O.E. to improve students ' skills in the 21st century, as well as growing their interest in studying STEM majors in universities and pursuing STEM professions (U.A.E. Vision 2030). In 2010, with the move to implement the Next Generation Science Standards (NGSS) of science curricula, STEM education has recently been introduced into the education system. STEM education is a new field in the United Arab

Emirates and Arab countries where insufficient work has been carried out on STEM education, especially in Arab and UAE schools (Ahmed, 2016; Tariq Rahim Soomro, 2019).

1.3 Purpose and Question of the Study

In the UAE, there is great attention to the process of educational development via the implementation of effective strategies and approaches and the implementation of new efficient approaches such as STEM PBL. To achieve the key educational goals, improve the academic achievement of the students and their participation in STEM education, this emphasis has increased. As little it is known regarding STEM learning in the UAE, there is an immediate need for additional researches to investigate the impact of STEM PBL on the students' achievement. Learning based on projects improves student achievement and has a positive impact on student self-efficacy as concluded by Bilgin, Karakuyu and Ay (2015).

The main purpose of the current study was to investigate the impact of implementing STEM Project-Based learning approach on elementary students' academic achievement in science compared to non-STEM PBL instruction in private school in Sharjah, UAE.

This research intended to answer the following question:

What is the impact of implementing STEM Project-Based Learning approach on elementary students' science academic achievement in Sharjah schools?

The following hypothesis was proposed to direct the study in order to answer the above question in detail:

There would be a statistical significant difference in the students' academic achievement between the students who were taught using the STEM PBL approach and those who did not.

The research was conducted at one of Sharjah's American curriculum schools The research was performed by a total of 112 grade five students. Data collection has been structured with a mixed method approach. The pretest posttest quasi-experiment was utilized in order to collect the quantitative data, were the qualitative data was collected through face-to-face a semi-structured interviews that asked students to elaborate thoroughly about their projects and the procedures they applied to reach their final design. As well as pointing out at the impact of the STEM PBL approach on their awareness, accomplishment and motivation.

Capraro (2013), defined the interpretation of STEM-PBL as an ill-defined problem within a well-defined outcome placed with a challenging contextualized task that allows learners to solve multiple problems which, when viewed in their essence, demonstrate student capability of several principles in different STEM disciplines.

1.4 Significance of the Study

The importance of this study is focused on testing the impact of STEM PBL on students' achievement through helping students recognize the problem and identify the limitations. Then examine and analyze the ideas that allow students to investigate the solutions then broaden their work by constructing a new solution and collaborate to figure out a new or better solution, and eventually the students used to evaluate, improve and report on their outcome. Throughout the study, the learners always used the integration between disciplines through STEM PBL. Furthermore, the value of research comes from the key findings of research on the effectiveness of incorporating the PBL approach with STEM instruction in enhancing students' 21st century skills such as problem solving, creativity, cooperation, and critical thinking (Miller, Sonnert and Sadler 2018). In fact, the integration of both STEM curriculum and the PBL approach shows the capability to improve the comprehension, interdisciplinary awareness and the willingness of students to effectively integrate the STEM disciplines. It does this by engaging them under the facilitation of a teacher in real-world problems (Lin, et al 2018) besides increasing the interest of students in pursuing STEM careers in the future (Roberts, et al 2018). As stated by many researchers, PBL is among the best approaches to STEM education as it can substantially improve the achievement of students (Craft & Capraro 2017; Han 2017). Recently, many researchers have shown a growing interest in learning based on the STEM projects to find its effect on learning for students.

1.5 The Structure of the Dissertation

The current paper consists of 5 main chapters. The introduction is the first chapter that emphasizes the importance of STEM education nationally and internationally, illustrates the background of the study, then addresses the research problem, then it presents the purpose and questions of this study, finally it emphasizes the significance of the study. The second chapter illustrates the theoretical framework and literature review in the UAE educational system known to U.A.E. education history, the STEM PBL approach and STEM education. The third chapter addresses the methodology and approach used to collect data in the current study, in addition to the population and the sample of the study. Instruments, research procedure, and ethical considerations also are presented in chapter three. The fourth chapter lays out a detailed summary of the analysis of the data and the key findings of the study. At last, the 5th chapter explains the main effects and states the conclusion as well as the recommendations and limitations.

Chapter 2: Theoretical Framework and Literature Review

The current chapter discusses the study's theoretical framework and relevant literature review.

2.1 Theoretical Framework

Overview and discussion of the main theories and models that form the present study theoretical framework is included in the theoretical framework section. It contains Drake and Burns ' Integrative Theory (2004), Vygotsky's Social Constructivism Theory (1978), In addition to the Next Generations Science Standards (NGSS 2013) framework established by the National Research Council (NRC, 2012) on K-12 Science Education.

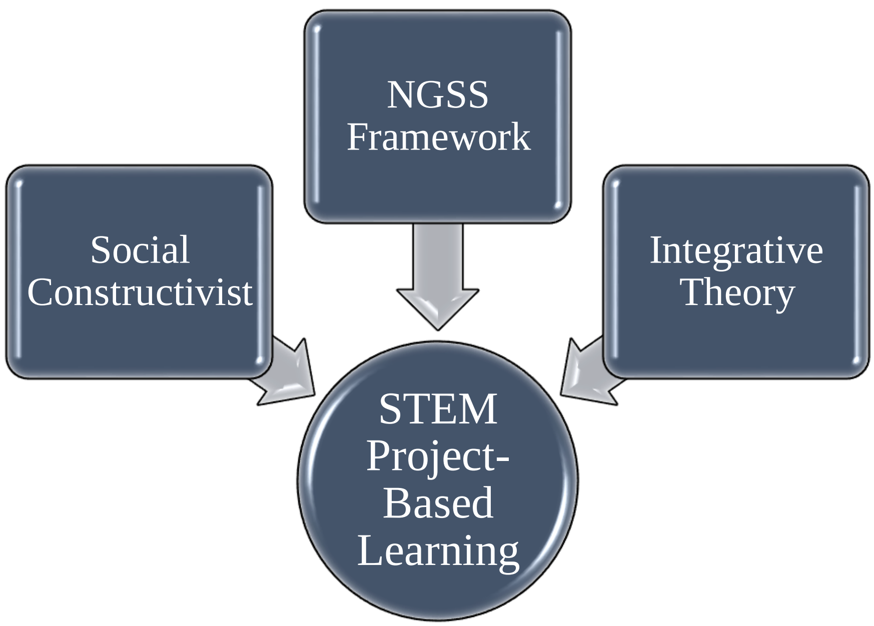

Figure (1): The Study's Theoretical Framework.

2.1.1 Integrative Theory

Integrative theory or integration of curriculum have different meanings to different people. For this, it is important that the term to be clearly defined before any integration study take place.

The theoretical works were reviewed to determine the differences and similarities in order to develop a definition that closely correlates with the general aim of field research using the theoretical work of Bybee (2013), Drake (2012), Fogarty (2009), and Jacobs (1997; 2010). It is defined by (Bybee; Drake; Fogarty; Jacobs) that curriculum integration is characterized as an academic method in which students study an integrated or interdisciplinary subject or curriculum in multiple subjects.

Additionally, it was highlighted by Chernus and Fowler (2010) that there are four key factors of curriculum integration that have to be presently active in order to define a learning experience as truly interdisciplinary: first, the learning experience content must be arising from two or more disciplines. Two, the learning experience of the subjects concerned must have a common intention. Three, appropriate content standards must be based on well-defined objectives. Four, the learning process must be centered in the sense of the real world. Standards and transparency guide the academic atmosphere for success and development in the world of today (Drake & Burns 2004). Learners are held accountable for more detailed information to sort, handle, and stock. Learners must be able to connect in order to meet their effectiveness in presenting a vast amount of information (Drake & Burns 2004). Reformers and researchers in education, including others who are interested with STEM education, indicated that one method of achieving and reaching expectations is through integration (Moonesar and Mourtada 2015). Multidisciplinary, interdisciplinary, and transdisciplinary are three different approaches where integration can be achieved. Therefore, interdisciplinary STEM approach is an active and practical way of promoting awareness and learning through subject areas. When focusing primarily on disciplines through Multidisciplinary integration, it includes integrating curriculum and teaching from two or more subjects around a specific 24-theme subject (Drake and Burns 2004).

A multidisciplinary curriculum can be developed in many different ways. Researchers proposed that teaching could be structured and delivered from a structural question, rather than from fragmented perspectives (Drake & Burns 2004). Teachers in the classroom to teach teamwork often use multidisciplinary integration in education. Educational reformers and educators advocate putting together assistance and connections from more than one discipline and agree that a multidisciplinary approach gives students a deeper understanding of a topic, or how to solve a problem (Moonesar and Mourtada 2015). For example, Poland's educational stakeholders used educational robots to introduce primary school to STEM education (SmyrnovaTrybulska et al. 2016). SmyrnovaTrybulska et al. (2016), emphasis in their study on the need for learners to be well prepared, especially in the elementary levels, with STEM-related skills. Optimally, workshops using kits to set up and code robotics are demonstrated as a novel form of youth and children's interdisciplinary learning. The researchers claim that robotic classes will have an effect on scientific, social and mathematical literacy growth (Smyrnova-Trybulska et al., 2016).

Transdisciplinary integration means coordinating curricula and teaching about the questioning of learners, where real-life setting is used in order to develop their comprehension of concepts and skills (Drake and Burns 2010). Whereas interdisciplinary and multidisciplinary integration requires the combining of several topics in order to provide an overview of a subject, concept, or problem, while transdisciplinary integration moves across disciplinary borders to promote and enhance education. Education is not compartmentalized, but instead explored throughout the inquiry's content and context, so that cohesive concerns and subjects are connected to curriculum (Drake and Burns 2010). It is therefore vital to recognize how topics are combined which makes it different approaches. Transdisciplinary integration is described in forms such as development comprehension, awareness and expertise of the 21st century, problem-based learning and project-based learning. Nevertheless, as interdisciplinary and transdisciplinary terms imply relational and comprehensive, it should be noted that the methods used in the transdisciplinary area can also be extended to the definition of interdisciplinary (Elias, 2006).

2.1.2 Social Constructivism

The theory of Social-cultural also known as social constructivism; it explains education as being more comprehensive and meaningful, allowing students to understand the cultural and social contexts in which they reside (Greene, 2005; Efland, Freedman and Stuhr, 1996). Lev Vygotsky's theory concerns not only about cognitive but also socio-cultural development (Bruner, 1990). Vygotsky stressed the role of interaction learning in the development of children in which interactions, dialog and cultural interaction between individuals form the social-genetic process (Moll 1990). Moreover, Vygotsky (1978) suggested that the zone of proximal development (ZPD) is what the students are able to learn with more experienced partners. Language was a main tool for socio-genetic growth invented by people to encourage thinking organization through interaction and cooperation. Students can be brought up to a higher level through instruction and communication (Bereiter & Scardamalia, 1992). Accordingly, Vygotsky claims that through interactive learning, students will develop their comprehension (Beyhan & Baş, 2010). Therefore, this constructivist paradigm illustrates how students gain a better understanding when they become active participants in the learning process. Students will therefore build and develop knowledge in accordance with their unique way. Although Chanlin (2012) acknowledges that the main premise in constructivism is the active involvement of students in developing their understanding. PBL thus endorses learners as a constructivist method of teaching, combines theory with experience, and utilizes cooperative abilities to solve the ill-defined problems they face (Capraro, Capraro and Morgan, 2013). Therefore, this method of teaching will recognize the multiple potential of students in the classroom because each one has a particular learning ability, which implies that they have different styles of learning (Senturk and Bas, 2010).

Papert (1991) introduced constructionist theory of learning, which argues that knowledge can be built in a learning sense that enables the learners to participate in the creation or layout of products, according to the constructionist philosophy of Vygotsky. Constructionism theory therefore focuses more on hands-on design activities in which learners are actively involved in the construction, production or processing of new products (Kafai and Resnick 1996). Typically, such designs are chosen and cooperatively designed to address the interests, styles of learning, and skills of learners. Papert revised and expanded the principle of learning-by-doing in order to make new models of learning-by-work more practical. As per this theory, the design process of the artifacts will encourage students to apply the knowledge they are discovering and creating to provide new ideas using digital tools available (Papert, 1980). In addition, the constructionist-learning culture emphasizes community members ' active participation as coaches or other mentors that can support learners in the process of learning. Some of the main learning concepts in this regard are drawn from the theory of constructionist and constructivist theories, creating awareness, cooperation, problems solving exploration, design and technology integration (Ah-Namand and Osman, 2018). In this regards, the present study is influenced by both social constructivist theory and constructionist theory by stressing the need to model meaningful STEM projects in a setting of social learning.

Social constructivism is the cornerstone of STEM PBL education and the current study based on the above, where students become actively involved in the learning process where they can develop their understanding, which helps in improving their academic achievement and develop their skills.

2.1.3 Next Generations Science Standards (NGSS) framework

The National Research Council completed K-12 science education in 2012. A system, which concentrated on both engineering and scientific firms. In 2013, the NGSS framework was developed based on the NRC (2012) vision that defines scientific and engineering practices, core disciplinary ideas and crosscutting structures in science classrooms for the next generation. The NGSS is adopted in most states in the USA and many countries in the Middle East and North Africa (MENA) (Simpson, Sunder and Gabler 2017). NGSS also developed a roadmap to engage student's in-group dialogue and to provide students with the skills and expertise they need for their future (Bartholomew 2015). The NGSS guidelines involve three dimensions describing STEM education components: core principles, engineering practices and scientific practices as well as interdisciplinary concepts. These dimensions must be embedded into curricula, standards, education strategies and assessment, according to NGSS (2013). The core concepts of disciplines concentrate on understanding of content, observation and reflective activities in an objective context (Peters-Burton and Moore 2016). In order to understand, clarify and analyze a phenomenon or authentic issue, certain key disciplinary concepts are important. The idea is called a central idea if it is a basic concept in the field is widely used in several disciplines, acts as a main tool in solving problems and can be taught (Bartholomew 2015). Core ideas must be concrete and encourage lifelong learning that allows learners to explain the phenomenon or issue in issue and find reasons for it as stated by Duncan and Cavera (2015).

Disciplinary core ideas were maintained to prevent representation of textbooks of an enormous number of superficial topics. Ducan and Cavera (2015) concluded that, rather than explaining big chunks about a concept students would consider the core aspects that help them address two concerns, how and why. Krajcik and Delen (2016) agreed that to increase centered STEM education and pedagogical content, certain criteria and criteria were required. Crosscutting concepts are interdisciplinary in nature and extend across disciplines, bridging disciplinary relationships in a way that makes sense of a phenomena or issue (Krajcik & Delen 2016). In addition, these concepts act as filters to explore phenomena from many angles, they are known to be instruments of thought, and students should be able to use them easily based on the nature of the issue or phenomenon being studied (Bartholomew 2015; NRC 2012). Engineering practices are focused on by the NGSS (2013) as Engineering practices reflect engineering activities, for example project design and building of prototypes (NGSS 2013). These practices also clarify the need to practice knowledge and skills (Moye, Dugger and Starkweather, 2014). Link and incorporate engineering studies in order to help solve problems (Shernoff, et al. 2017). Moreover, engineering education through design would contextualize the experience of learners and discuss how and why a specific issue arises as stated by the NRC (2012). As stated by Marulcu and Barnett (2016), engineering practices improve the understanding of science and mathematics, enhance the use of technology, and connect with social needs as they address authentic scenarios. Best engineering practices are those that make engineering thinking the routine of mind: performing engineering investigations to determine the required design criteria, incorporating mathematical thinking, solving design-related problems, developing proof of the approach decided (Kelley & Knowles, 2016). Krajcik and Delen (2016) claim that both scientific activities and engineering are common and hard to be split. The same perspective was expressed by Lesseig et al. (2015), who discussed the project cycle between science and engineering processes as a company; first asking questions; second define the problem; then prototyping; next model building; then evaluating and analyzing the model; and finally updating and restructuring.

Based on the previous the NGSS framework is related to the current study where the STEM education is embedded in the framework where the integration of engineering practices help in enhancing the students understanding of the related topics.

2.2 Literature Review

In this section, a detailed view of the study literature is provided. This section poses the study-related synthesized major literature themes. This covers STEM education, PBL, STEM and student achievement STEM and motivation, science education, and STEM programs reforms in the UAE.

2.2.1 UAE Reforms in Science Education and STEM Programs.

The Education Vision 2020 is a five-year plan to improve teaching and training quality. This aims to improve the educational system of K-12 and prepare students for STEM challenges in colleges and future professions by introducing STEM curriculum in K-12 (Burton and Warner 2017; UAE Vision 2030; Warner 2018). Furthermore, technology has improved across classrooms to develop the skills needed for the future careers of the students of the 21st century (Warner 2018; UAE Vision 2030). The UAE Vision (2021) was launched to establish a "first-aid education system" by His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice-President and Prime Minister of the UAE and Dubai Ruler. The most optimistic goal of the United Arab Emirates Vision 2021 is to render the UAE one of the world's best countries and to bring this vision into action and increase student achievement in foreign testing; Sheik Mohammed bin Rashid Al Maktoum announces eight pillars of progress.

The labor market and the quality of education have changed the nature of the jobs required in the UAE (Farah 2012). According to the 2021 UAE Vision, emphasis was placed on STEM, by increased financial contributions in graduate programs and research, growing STEM enrollment and expanding collaborations between education and professional growth in the country (UAE Vision 2021). The need to implement advanced education initiatives, such as STEMs and creative educational strategies, for example, the PBL, is illustrated by a recent reform agenda in order to meet UAE education standards (UAE Vision 2021 2015).

2.2.2 STEM Education

Enhanced education in STEM is important for many nations in the growth and economic stability sector because of the social and environmental pressures of the 21st Century (Carlisle and Weaver 2018; Kelley and Knowles 2016; English 2017).

STEM education is a teaching strategy that includes two or more disciplines of science, technology, engineering, and math (Kelley & Knowles 2016). Because of the direct link between real life and problem-based learning, in solving these problems, there are usually two or more subject areas included. The STEM has been identified as a clear result, with an ambiguous task by Sahin et al (2015). STEM is no combined with four different disciplines, but it also includes teaching practices that rely on constructionism and constructivism, according to Wise Lindemann and McKendry (2015). Lewis, Capraro and Capraro (2013) therefore also proposed that STEM PBL is developed based upon constructivism, in which students have a chance to work in communities and in realistic projects under an interdisciplinary setting to address open questions. According to Walker (2017), the use of integrated STEM is a successful way to promote the aspirations and achievement of students by enhancing their scientific knowledge and connecting the STEM disciplines effectively, besides mastering other professional skills (Khalil and Osman 2017). As per Kelley & Knowles (2016), it is considered integrative STEM to involve learners in comprehensive curriculum with related instructions in science, math, and engineering design in order to solve a real-life problem. In order to develop a thematic experience Asunda and Mativo (2016) proposed incorporating math and science principles into engineering and technology. In introducing integrative STEM, Honey, Pearson and Schweingruber (2014) proposed three implications: Integration should be clear in order to acquire knowledge and skills through project-based learning as well as problem-based learning inside and across the disciplines and in order to enable learners to produce adequate ideas in an integrated sense. Combining science analytical reasoning and concept of mathematics could enhance engineering education (NGSS 2013). As shown in figure (1) below, the integrative STEM as a load carrier four pulleys system has been demonstrated by Kelly and Knowles (2016).The four load-lifting pulleys are scientific inquiry mathematical reasoning, engineering design and technology. The four pulleys are attached to the practice rope; the four pulleys will work in synchronization to bear the STEM learning load.

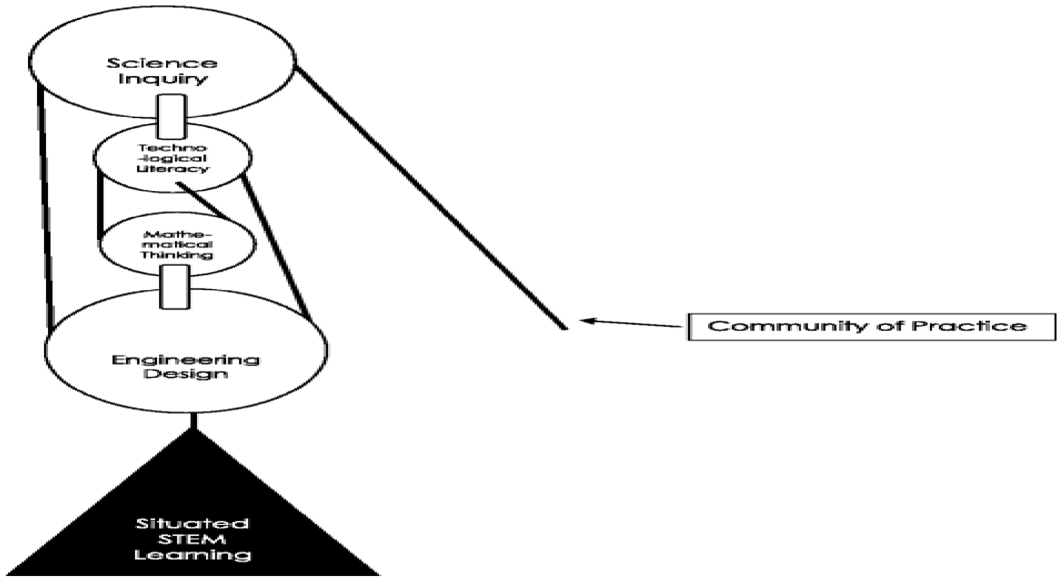

Figure (2): The integrative STEM adopted from Kelly & Knowles (2016)

Integrating STEM is a crucial part in the process of educational reforms aimed at promoting curriculum development and student achievement (Kelley and Knowles 2016; English 2016). Enforcing integrated STEM curriculum has a major impact on the next generation interest in STEM career choices; STEM learning, 21st-century skills and student performance (Dejarnette 2016; Baran, et al. 2016). According to English (2016), it is vital to promote the four disciplines in order to promote STEM integration and to improve the interdisciplinary process in addition to the knowledge of the content. No ideal way of promoting STEM education is available because it depends on schools, curricula and politics (DeCoito, 2016).

2.2.3 Project-based Learning (PBL)

Utilizing PBL in STEM education is a dynamic approach for improving the learning experience of learners and equipping learners with the 21st skills required for their future (Jamali, et al. 2017). STEM PBL is an interdisciplinary approach described as an undefined task with a well-defined outcome or design established in a contextually rich challenge to solve several issues, which demonstrate a student's awareness of multiple concepts in particular STEM subjects when presented in their entirety (Han, et al., 2015; Capraro and Slough, 2013). Furthermore, it was described as an approach to instruction in the STEM education by El Sayary, Forawi and Mansour (2015). In many areas, PBL has long been used, such as in infrastructure IT, economy and the medical industry (Capraro, Capraro & Morgan 2013). Problem-based and project-based learning differ, with project-based learning providing more problems and dilemmas which helps learners to have more expertise and answers in more than one field. It improves self-efficacy and builds new, longer-lasting awareness (Capraro, Capraro and Morgan 2013). Thus, through STEM project-based learning, problem based learning is submerged. Using PBL is challenging for learners due to challenges that can occur when designing a project, and because of these challenges, it often creates cognitive challenges that improve high-level thinking skills, motivate students to learn and to be self-reliant if their teachers effectively direct the students (Kokotaski, Menzie and Wiggins, 2016). Gonzales (2015) claimed that PBL allows learners to work collaboratively, connect, build and think critically. Hall and Miro (2016) stated that through trial and error STEM (PBL) could give students a deeper self-regulated understanding. Capraro, Capraro and Morgan (2013) claimed that STEM PBL approach is the best engineering method illustration; it reflects the engineering design cycle as shown in Figure (2) below.

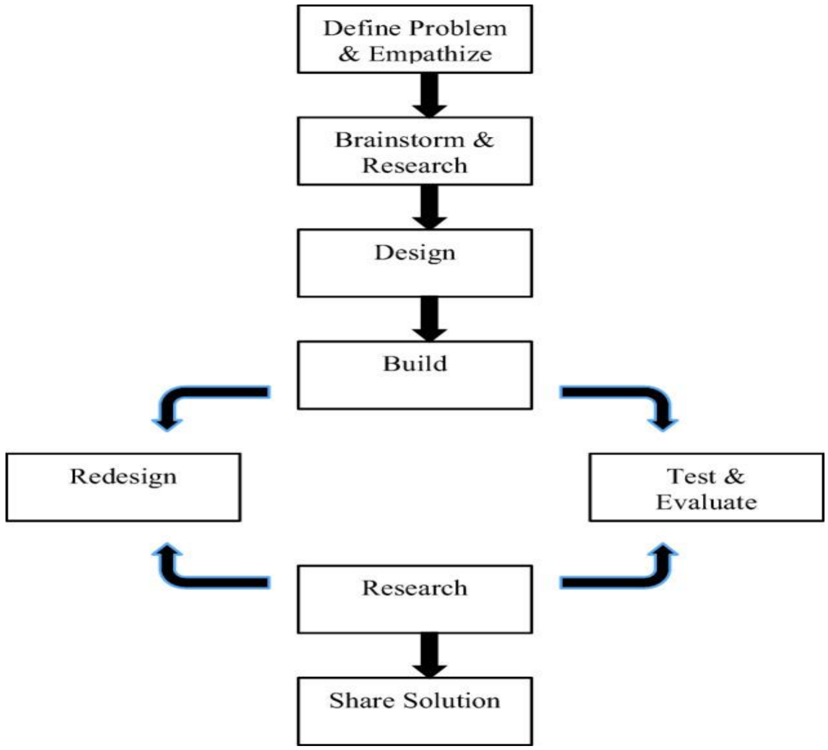

Figure (3): Engineering design process adapted from Lesseig, et al. 2016

As shown in Figure (2), the engineering a task or design issue drives design process; learners are researching to gather information from various disciplines. Then they are developing initial thoughts about the issue, applying the principles of math technology and science to evaluate available data, designing a model and constructing a prototype; evaluating prototype execution is a key stage in giving a chance defining and finding the optimum solution, and eventually interacting with others and discussing it. the core elements of effective engineering design as it ought to be genuine that it can be carried out using available equipment and materials, it will provide potential for several design solutions, the project can be enhanced and replicated, and must be carried out collaboratively (Altan and Ercan, 2016).

STEM PBL is based on a constructivist theory of education that helps learners to focus on their experience and comprehension through a meaning-building process to produce their own content (Han 2017). Ralph (2015) also considered the STEM PBL to be a pedagogical application of constructivist theory. There have been few previous studies reporting on the effects of STEM PBL implementation. Nevertheless, lately, STEM PBL has become a central strategy in the school environment because of the effective engagement of learners in real-life activities and research capabilities to promote academic achievement, improve learners ' interdisciplinary experience and develop their skills (Han et al. 2016; Craft and Capraro 2017). PBL is known as an effective teaching method, which offers contextual and realistic interactions to build a substantive comprehension of STEM (Hall & Miro 2016; Roberts et al. 2018). Furthermore, Lou, Tsai, Tseng and Shih (2014) discovered that the integration of PBL with STEM education has a positive influence on STEM learning for learners. In addition, Hall and Miro (2016) reported that the use of the STEM PBL approach in classes promotes the development process of STEM education by incorporating PBL methods including learners' self-assessment, group work, and educator feedback challenging approaches as well as topic area incorporation. Moreover, Wallace and Webb (2016) reported that the introduction of communication-intensive courses improved instructional support for the successful execution of a PBL approach in STEM classes.

2.2.4 STEM Education and Student Achievement

Arguments and debates on the best educational approach have included several forms of studies in the educational sector (Hwang and Wang 2016). Some researchers believe that direct instruction is best way of teaching, whereas others claim that giving young learners the opportunity to build their skills will be more efficient in learning deeper (Ozverir, Osama, & Herrington, 2017). Deep learning can be accomplished via successful comprehension and self-construction, resulting in higher learning outcomes across learners and higher achievements

(Pegrum et al. 2015). When they gain comprehension, learners connect to existing knowledge to new knowledge through the critical analysis of ideas to improve their awareness and retain their knowledge for longer (Pegrum, Bartle & Longnecker, 2015). Consequently, learners should be engaged in the learning process in order to establish deep comprehension in science education. This can thus be combined with the project-based approach in the teaching sciences. This will also help to develop a clear understanding of scientific ideas that will enhance the retention and acquisition of knowledge (Lee et al. 2014). As stated by Slavin (2014) when learners are actively engaged in cooperative learning they can achieve a higher level of achievement relative to others learned based on traditional ways. PBL encourages learners to develop their skills of the 21st century, such as teamwork, communication, creativity, problem solving and critical thinking, in order to build a well-equipped individuals for STEM careers (Akundi 2017; El Sayary, Forawi & Mansour 2015; Husin et al, 2016).

Many studies have found that there is a huge difference in the achievements of the student between STEM education and traditional teaching approaches. They discovered that the results of the student's improved and their ability to learn while using STEM approach increased (Bilgin, Ay, and Karakuyu 2015). In fact, the PBL approach ensures that the student achievement in STEM subjects is improved efficiently (El Sayary, Forawi & Mansour 2015; Han 2017; Craft & Capraro 2017). Han, (2015) confirmed in his study the positive impact of STEM PBL approach on the achievement of learners when socio-cultural factors have influenced their actions and attitudes. Hathcock et al. (2015) claimed that ill-structured issues such as those in STEM and inquiry provide learners with great opportunities to find solutions that show their creativity to provide innovative responses to these concerns. The ability to address these ill-structured questions, though, plays a crucial role. The averages for STEM learners were above the non-STEM learners' averages as reported by Nelson et al. (2011). Han (2015) listed other reason for the introduction of STEM projects at school, which are the socio-cultural influences on both the behavior, and attitudes of learners. Students work cooperatively in teams making decisions help them achieve social maturity.

2.2.5 STEM and Motivation

Tseng et al. (2013) claimed that STEM PBL is more optimistic than academic performance in promoting achievement. Comparing learners who used to learn through traditional teaching approaches and students who completed the term using STEM PBL demonstrated more enthusiasm for learning with more cooperation in collaborative teams, and more communications skills. In fact, STEM PBL has shown a considerable increase in the self-confidence and performance of the participants. Wilhelm (2014) proposed that STEM PBL would affect and improve the perception of the students as well as their achievement in mathematics. In the other hand, Han (2013) claimed that not all learners have reached the same level of achievement after using STEM PBL, under average, however, students showed less improvements in academic performance, while above average students showed better progress. The research also identified another element that can influence students ' academic achievement, such as English language abilities and community impact. Instead of the traditional method, Yoon (2009) suggested high or medium learners to student-centered education in the collaborative environment. Yoon considered learners more self-directed here, whereas the educator is in a positive learning environment to provide encouragement, direction and formative feedback to the students. It offers learners the opportunity to make every effort to fulfill teachers ' high expectations which will lead to the improvement of their achievement. On the opposite, students who are below average are less self-directed learners and less motivated toward learning, if they are not under constant supervision, they often get distracted and off-task. On the other hand, Han (2013) claimed that in a student-centered setting, STEM PBL approach has a more positive impact on the achievement of low-average learners. Even, for the above average students, the above average group showed a significant improvement in achievement, while below average students had less improvement. Han (2014) asserted that two significant factors affect student achievement: first the learning environment, which is the STEM PBL, and second the ability of the learners, which divides into many other sub-factors. Therefore, if STEM PBL were the learning environment, student achievement would significantly increase.

Gülhan and Sahin (2016) (in Ugras, M. 2018) examined the influence of incorporation in science, technology, mathematics, and engineering on students ' views and attitudes towards these fields. Over 12 weeks each, the STEM activities they created were extended to the students and it was decided that the students ' STEM expectations and STEM attitudes improved as a consequence of the curriculum. Yamak, Bulut, and Dundar (2014) (in Ugras, M. 2018) concluded in their research the effect of STEM practices on scientific process abilities and attitudes of fifth grade students towards science It was assumed that the STEM programs strengthened the knowledge and perceptions of the students towards science in the scientific process. Chittum et. Al (2017) studied the impact of the STEM after-school activities on the attitudes of the pupils and found that the student motivation improved after the program. In a report, by contrasting STEM-based schools and non-STEM-based schools in STEM fields, Güzey, Harwell and Moore (2014) found a significant gap in favor of students attending STEM-based schools. Rehmat (2015) also stated that problem-based STEM practices improved fourth grade student STEM attitudes. It could be argued that STEM practices improve the students ' STEM attitudes according to the above described studies.

Chapter 3: Methodology

STEM PBL education in the 21st century has drawn the attention of many educators all over the world. Over recent years, the national programs in the UAE that promote innovation in STEM have increased in dramatic way. It included empowering schools to carry out STEM initiatives. There are many goals of introducing STEM PBL programs, such as empowering students with the skills required to achieve, excel their future careers. Skills such as creativity, problem solving, communication skills, critical thinking, and inquiry skills.

The aim of the current study was to study the impact of implementing STEM Project-Based learning on elementary students' academic achievement compared to non-STEM PBL instructions in private school in Sharjah, UAE. This chapter present the development and methodology of this research study. The quasi-experimental research design used in the current study is addressed in this chapter along with the location, sampling and participation, instrumentation, data analysis, validity, and ethical concerns.

3.1 Research Design

The current study followed the explanatory sequential mixed approach using both quantitative and qualitative models with start and focus on quantitative approach. The mixed method approach is defined by Creswell (2009) as the process of both quantitative and qualitative data acquisition and analysis within a study. As stated by Lund (2012), the analysis of mixed methods approach is more practical than qualitative or quantitative isolated methods for a complete picture of the subject testing to provide accurate answers to complex dilemmas. Combining qualitative and quantitative methods has two main advantages. First, combining both approaches should allow data analysis to better improve the results. Secondly, this combination would open new lines of thought through the resolution of contradictions from the various data sources (Mayoh, Onwuegbuzie, 2015). Moreover, such contradictions can lead to even more thought, consideration, adjudication, and analysis. It also guarantees the proper assembly and analysis of the results Lund (2012). Quantitative and qualitative approaches have variations in positive and negative aspects that reinforce one another and hence improve the study's findings (Mayoh and Onwuegbuzie, 2014). Creswell, (2009) assert that the qualitative approaches analyze situations from the viewpoint of the participants. It is therefore taken from the constructivist philosophy that respondents were able to create their understanding of the circumstance. Qualitative analysis thus aims to analyze the social meaning through participants' anxiety and assimilation of the phenomenon examined (Mayoh & Onwuegbuzie, 2014), this could also help to carry out a given form of daily events relevant to the participants that is related to the research topic (Frederick and Erickson, 2012). In which it will help to achieve broader and deeper outcomes (Lund, 2012). Quantitative analysis, on the other hand, contributes more to hypothesis testing and often provides more generalizable and consistent results of a research than qualitative approaches (Lund, 2012). The mixed model approach has the advantage that you can use both quantitative and qualitative methods to escape their limitations (Lund, 2012). Creswell (2008) promotes the processing and analysis of various data based on the philosophy of pragmatism. The pragmatist philosophy only accepts ideas as valid when they endorse practice. Pragmatics consider that there are many different interpretations of the world and research that there can never be any single view, and there can be many prospects (Saunders, Lewis & Thornhill, 2012). Research question is the most important determinant of the study methodology, according to pragmatism research Philosophy. Johnson and Christensen (2012) proposed the use of both quantitative and qualitative approaches. It causes all issues to be explored by the researcher and give a better understanding of the analysis. The main reason in this analysis to choose and use the mixed model approach is that the research problem requires both quantitative and qualitative data to be gathered (Creswell, 2014). Therefore, the combination of both quantitative and qualitative methods, as per Creswell (2013), provides better understanding, because this is capable of answering research questions thoroughly. The pragmatism philosophy has therefore been followed, as it is a good basis for undertaking academically coherent and rational work in the mixed-method methodology (Creswell, 2014). The Most important factor of adapting pragmatist philosophy is that the pragmatist philosophy focus on the purpose of the research rather than the process of the research.

Quasi-experimental approach was used in order to collect the quantitative data for this research. Experimental research is among the most effective research methods to identify the cause-and-effect relationships between variables and attempts to affect a single variable (Fraenkel, Wallen & Hyun, 2012). The quasi-experimental method is defined as experimental conditions in which the researchers assign subjects to classes, but not randomly, because the experimenter cannot create artificial experimental groups (Creswell, 2012). In comparison to other methods, the variables are more regulated than any other type of research in experimental studies and the risks that could influence the internal validity of the test are reduced (Fraenkel, Wallen & Hyun 2012). Therefore, random selection of controls and study groups in educational research is not always feasible, and it will interrupt the classroom (Cohen, Manion & Morrison 2007, Creswell 2012). Wherefore, an experimental group design with naturally occurring comparison groups is chosen to be as closer as possible (Fraenkel et al. 2012). Therefore, one of the major advantages of the quasi-experimental study is to analyze the phenomena in their natural setting that meets the study's external validity while retaining medium to high control.

In the quantitative part, a pretest-posttest quasi-experiment was carried out in order to fulfill the study purpose to find the impact of STEM PBL approach on students' achievement. As such, the purpose is to find the effect of STEM PBL approach, which is the independent variable on the students' achievement, which is the dependent variable for the experimental group. The design of the experiment is shown in figure 3.

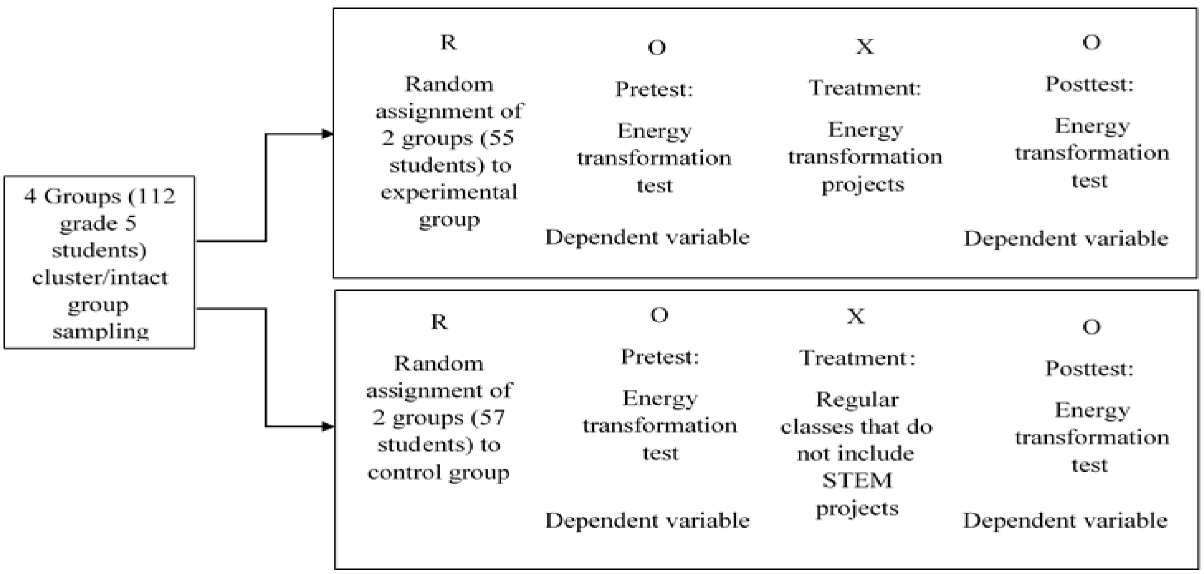

Figure (4): Pretest-posttest quasi-experiment design

After finishing the experiment and collecting the data quantitatively, 6 open-ended questions were used through face-to-face semi-structured interview to collect the data qualitatively (See Appendix 1).

Explanatory sequential mixed-methods approach was utilized in the current study in which the data are collected and analyzed quantitatively first, and then qualitative data were collected in order to fully explain the quantitative data results (Creswell, 2014). It is called descriptive because quantitative data findings were later explained using qualitative data. Therefore, the quantitative process is performed in a series before the qualitative phase (Creswell, 2014).

The reason behind choosing this approach is the gap to be studied. In the case where the data are not available in the literature the researcher start with the qualitative data first then follow up with the quantitative data in order to generalize the results. If there is available information in the literature, on the other hand, the researcher begins with quantitative data collection, then analyses is carried out with the qualitative data so that the results of the current study can be fully explained (Creswell 2014).

3.2 Site

The current study was carried out in Sharjah private schools within the UAE context. Due to the MOE's strong attention to the academic reform process and the introduction of STEM education in schools curriculums (UAE Vision, 2030); the selected school is suitable for carrying out this study. The current study was carried out in private school in Sharjah that follows the American curriculum, which adopt the NGSS standards where the researcher works. The explanation why this school was selected because of the great attention that the US pays to STEM education to help the economy. This attention was reflected in the curricula of science, computer science and mathematics. Next Generation Science Standards (NGSS) emphasis in their lessons on STEM practices, so all American-system schools across the globe that implement NGSS become influenced by this commitment to teach STEM to a certain level. In addition, education institutions in the U.A.E. enforce regulations on schools to introduce innovative curricula that increase active learning, improve communication skills, build a conducive and stimulating learning environment, encourage an innovative teaching environment as well as critical thinking skills (MOE, 2010).

3.3 Study Procedure

The current study followed different stages. First, a pretest was given to both groups experimental and controlled group, but only on the experimental group were applied STEM PBL activities. Then, the experimental group went through different stages. At the beginning, the teacher directly presented to students the topic of energy transformation in order to introduce them with a clear idea of energy and different energy forms. The students were subsequently randomly divided into groups during the second phase and had to use everything they learned to develop an idea that shows energy transformation then to build their own model. During their investigation, the teacher instructed and offered them three different ideas: solar powered boat, balloon powered car, and thermal windmill. In fact, the teacher gave the students the opportunity to create their own ideas for their design projects in order to allow them the opportunity to demonstrate their comprehension of the topic in their research. Then, students modeled their prototypes on papers and then proceeded in creating their models, reviewing their research themselves. Finally, students were asked to compose formal writing to clarify how their design is created and what kind of energy transformation their project reflects. The posttest was then conducted with both groups to measure the impact of the treatment on the experimental group and to assess the difference between the two classes. In a quasi-experimental design, “the researcher does not use random assignment of participants to groups" (Fraenkel el al. p.275) however, to minimize the risks to the internal validity of the research, the intact groups are randomly assigned to the treatment. So that the experimental group can ideally develop their achievement in the science classes by doing STEM projects.

Eventually, in order to learn about their projects and practices, and to know more about their comprehension and enjoyment with that knowledge, the researcher interviewed ten of the students at the last stage. The interview was conducted at the school, where the students were required to answer some questions. The researcher provided the participants with simple information on the research and the purpose of this interview. The interview was recorded on audio. The interviewees spoke about audio recorder use and decided before the interviews. Participants were assured of confidentiality of their anonymity. Appendix 7 shows some pictures of student work.

3.4 Sampling and Participants

The current study was conducted in a K-12 American curriculum school over a five-week period with 112 grade five students, from the boy's section in private school in Sharjah, UAE. The researcher taught all the science classes. As an American school, the language of delivering the lessons and communication is the English language. At this school, students enter grade one at the age of six and finish grade 12 at age of 18. In the elementary section, most of the classes have 27 students in each class in average where boys and girls are separated in different classes from grade 4 until high school. The total number of the participants is 112 grade five boys' elementary students. The reason behind choosing this sample for this study is that the researcher is the teacher for these classes. The participants were only boys between the ages of 9-10 years. Differences between control and experimental group during a quasi-experiment are expected such as age, learners' achievement levels in science and different skills that could affect the independent variables (Fraenkel et al. 2012). As a result, a pretest-posttest quasi-experimental design with naturally occurring comparison groups was considered the best approach to increase the study's internal validity. The sampling method in the current study is a cluster random sampling where existing clusters or intact group, which are the classes, have already been selected by the researcher to be randomly assigned to experimental and control groups

(Fraenkel, Wallen & Hyun, 2012). Four classes were randomly divided into two groups, two experimental and two control groups.

The majority of the students had the same cultural background where most of them where Emirate students. Based on the pretest results students' average academic achievement in science which represent an equal student distribution in control groups and experimental groups as presented in table 1 below.

Table (1): Students' Average results in the pretest.

Group	Number of Students	Mean	Standard Deviation
Group A (control)	29	2.7	1.63
Group B (control)	28	3.8	1.78
Group C (experiment)	27	3.6	1.98
Group D (experiment)	28	3.3	2.09

3.5 Instrumentation

Data collected by qualitative and quantitative methods in two different ways. A test was developed by the researcher in order to collect the data needed for the quantitative part (See Appendix 2). The test consists of 11 multiple-choice questions about the energy transformation topic. The energy transformation test focus on measuring the students understanding of the energy and the conservation of energy concepts in addition to the changes between different types of energy that occurs in real life applications. 112 copies of the test were printed out and distributed to the student before and after the experiment.

Qualitative data were collected through semi-structured interviews using six open-ended questions related to the aim of the research (See Appendix 1). The researcher interviewed ten students from the experimental group 5 students from each class in the school where they were asked to express their STEM PBL experience. Then their responses to open-ended questions are taped in order to get participants' perspectives (Creswell, 2014). The respondent has the right to decide his responses, explanations and how much to talk in semi-structured interviews (Kasim and Al-Gahur, 2015). In fact, it is at the discretion of the interviewer to address the different subjects and the nature of the questions (Corbetta, 2003). In fact, Gray (2004) suggests that this style of interview provides the interviewer the freedom to analyze and evaluate the interviewee's perspectives.

The interviews consisted of six questions; the first three questions focused on the projects they performed and the steps they went through in order to accomplish their project and if they faced any difficulties through the project and how did they solve it. The next two questions asked the participants to express their experience through STEM PBL and the new skills they developed through this experience. The last question asked the students where they see themselves working in the future. The interviews and the test included questions about real-world issues, teamwork, problem solving, technology use, critical thinking and creativity.

3.6 Validity and Reliability of Study

Validity and reliability checks for instruments being used in a research is important as stated by Creswell (2014). Validity is the degree to which a question tests what it was meant to measure to generalize the findings (Johnson 2014). Validity tests include validity of content measurements, questions and validity of the format (Johnson 2014). The test used in the quantitative part and the interview questions in the qualitative part was revised by a university professor who recommended changes to certain items to confirm the validity of the tools used in this research. Moreover, two science teachers who are teaching grade five revised the test to solidify and tighten the content of the test. In addition, one English teacher revised the test in order to eliminate any language problems in the test. Quasi-experimental research aims to show the circumstances under study in real-world situations and thus enhance external validity of the study (Heinsman & Shadish, 1996).

Reliability applies to a set of test scores remaining consistent or stable if a test or assessment technique provides accurate results, the scores will be identical on any occasion (Johnson 2014). Test and retest is one way of measuring the reliability of a research tool using correlation coefficient (Johnson 2014). The reliability calculations of the test used in the study after the students did the pretest and posttest are presented in the next chapter.

The researcher being the teacher, who did the planning for the projects and carried out the stages of the research in the place where the research was conducted, assured the trustworthiness of the data collected and the results. Moreover, the researcher was with the students gradually and he was responsible of collecting the data from the students by conducting the pre, posttests and the interviews. The researcher's participation in these steps in collecting data has improved the reliability and validity of the research as he had a clear idea about the studied phenomena.

3.7 Data Analysis

After conducting the stages of the study, collected data from the quantitative and qualitative parts were analyzed in order to answer the research question. As stated before, the current research followed the explanatory sequential approach, as a result, the quantitative data were collected and analyzed first then the qualitative data were collected to support and solidify the results. Quantitative data were collected using the energy transformation test. Experimental and control group results were collected and saved in an Excel file and then statistically analyzed using the SPSS software. Parametric analysis was needed since there were more than 30 participants (Field, 2009). In order to answer the research question descriptive and inferential statistical tests have been used to find if there is a significant statistical difference between the experimental group and control group in the mean of the students' results in the pre and posttest and within each group in order to test the study hypothesis (Field, 2009). Qualitative data were collected using semi-structured interviews. Students' answers were audio taped and analyzed. Analysis of the qualitative part for this study (semi-structured interviews) will adopt the type of themes (Crsewell 2014). Since this part is subjective, the researcher gathered responses from all students and then analyzed them in order to specify the main themes and perspectives. This method of study is referred to as the inductive process in which the researchers derive importance from data collected in the field (Creswell 2014).

3.8 Ethical Considerations

When conducting research, ethical issues should be foreseen (Bryman & Bell, 2011). Gajjar, (2013) points out that alignment with ethical standards is essential in research because it can help validate study goals such as inventiveness and trustworthiness and anomaly avoidance. In order to ensure the applicability of all ethical standards in the present study, the researcher consulted with the Primary School Manager, Head of Academics and Head of Science. During the meeting, the researcher explained the purpose of the research and how it will be conducted in their school. In fact, an official letter from the British University in Dubai was sent to school management requesting permission to undertake this research (See Appendix 3). The researcher ensured that the identities of the students were anonymous. School name was assured for the school management that it will remain anonymous and the results will be used for the purpose of the research only (Creswell, 2014). School admission was informed that they could withdraw from participating in this study at any time and without any penalty. The participants have had the freedom to participate in this experiment and have been informed that they can withdraw from the study if they think they should do so at any time. They were also told that they would value their integrity and confidentiality. Consequently, in respect to what was previously stated, all the recommended ethical standards were discussed during this review, focusing on all the points accepted with the school administration. After collecting the data, data analysis and the results are presented in the next chapter.

Chapter 4: Results and Data Analysis

The current study was carried out in order to study the impact of implementing STEM PBL approach on elementary students' achievement in science in the UAE. This chapter presents a comprehensive and thorough analysis of the results after collecting qualitative and quantitative data. A pretest-posttest quasi-experimental design was used in order to collect the data quantitatively. After completing the quasi-experiment, many interviews with the students were carried out in order to collect the data qualitatively where they were asked to provide a feedback about their projects and evaluate their experience.

4.1 Quantitative Results

In order to meet the study aim, a pretest-posttest quasi-experimental design was implemented to assess the impact of implementing STEM PBL approach on elementary students' academic achievement in science classes. Therefore, the aim is to assess the effect of STEM PBL approach, which is the independent variable on the elementary student's academic achievement, which is the dependent variable for the experimental group against the control group where STEM PBL approach was not used. This research was carried out at a K-12 privet school in Sharjah that follows American curriculum. The participants were hundred and twelve grade five boy's students. One hypothesis have been formulated in conjunction with the research intention to direct the study's analysis to address the study question: what is the impact of implementing STEM PBL approach on the science academic achievement of elementary students?

The hypothesis that guided the research analysis was: There would be a statistically significant difference in student achievement between students who have been taught using the STEM PBL approach and those who have not.

The SPSS statistical tool was used to interpret quantitative data by using different forms of statistical tests in order to address the research question and analyze the data collected. First, in order to test the influence of an independent variable on dependent variables, the data obtained from the pretest was analyzed using One-way ANOVA test for the experimental and control groups in order to assess whether the groups are equal and the sampling is appropriate. Second, descriptive statistics were applied to compare the mean scores of experimental group and control group in pretest and posttest where paired t-test was used in order to find if there is any statistically difference between their pretest and posttest scores for both groups. Finally, the differences between control and experimental groups in posttest scores were analyzed using an independent T-test, to determine whether the two group scores differ statistically significantly.

4.1.1 Equivalency and adequacy between experimental and control groups in the pretest.

One hundred and twelve grade five boys' students in four different classes were the participants in this research. Randomly, the four classes were divided into two groups. Class A (29 boys students) and class B (28 boys students) where the control group with a total number of 57 students. The experimental group consists of class C (27 boys students) and class D (28 boys students) with a total number of 55 students. To order to assess the equivalence of the 4 classes the four classes have been pretested and the results compared. Table 1 in chapter 3 showed the averages for each class, the averages are as follow: class A (2.7), class B (3.8), class C (3.6), and class D (3.3). The averages for all classes are close to each other and showed that there is no difference between the classes. In order to find if there is any statistically significant difference between the averages of all four classes One-way ANOVA test has been used. The results are presented in table 2 below. Students' results in the pretest for all classes are presented in Appendix 4.

Table (2): One-way ANOVA test analysis between the control and experimental groups.

<table>
<tr><th>Sources of Variance</th><th>Sum of Squares</th><th>df</th><th>Mean Square</th><th>F-Value</th><th>P-Value</th></tr>
<tr><td>Between Groups</td><td>20.081</td><td>3</td><td>6.694</td><td rowspan="3">1.825</td><td rowspan="3">0.147</td></tr>
<tr><td>Within Groups</td><td>396.189</td><td>108</td><td rowspan="2">3.668</td></tr>
<tr><td>Total</td><td>416.250</td><td>111</td></tr>
</table>

Table 2 indicates that there is no statistically significant difference between the pre-test scores for the students of the four classes composed of the experimental and control groups where the P-value = 0.147 > 0.05. That indicates a strong degree of equivalence between them. Therefore, experimental and control groups have similar starting points prior to treatment, as a result the current study may be considered suitable for the current classes.

4.1.2 Differences between pretest and posttest results of the experimental and control groups.

The first level of analysis is to compare students' pretest and posttest scores for both experimental and control groups to determine the impact of the STEM PBL approach on students' achievement. A paired t-test and descriptive statistics were used to determine whether there is any significant difference between the students ' pretest and the posttest results for both experimental and control groups. The results are shown in table 3 below. Full analysis presented in Appendix 5. Students’ results in the posttest for all groups are presented in Appendix 4.

Table (3): Descriptive statistics and paired T-test results between the pretest and posttest results of both the experimental and control groups.

Group		**N**	**Mean**	**Std. Deviation**	**t**	**df**	**Sig. (2taile)**
Experimental Group	Pre-test	55	3.47	2.062	11.544	54	.000
	Post-test	55	7.38	1.727			
Control Group	Pre-test	57	3.28	1.820	9.495	56	.000
	Post-test	57	6.07	1.624			

Based on the paired t-test results presented in table 3 above it is observed that there is a strong significant difference between the pretest and posttest results for the experimental group $t(54) = 11.544$; $P < 0.05$ where the significant value $p = 0.000$. For the control group it showed also that there is a statistically significant difference between the pretest and posttest results where $t (56) = 9.495$ and $P = 0.000 < 0.05$. Moreover, Table 2 above indicates that the scores average in the experimental group was 3.47 out of 11 with a standard deviation of 2.062. The scores mean of the experimental group improved to 7.38 with standard deviation of 1.727 after being subjected to the STEM PBL approach for 5 weeks. Likewise, the control group's scores mean in the pretest was 3.28 out of 11 with a standard deviation of 1.820 and their scores mean was 6.07 with a standard deviation of 1.624 after 5 weeks learning about the energy transformation topic without the use of STEM PBL approach. The difference between scores means of the pretest and posttest for the experimental group was found to be 3.91, which is greater than the difference between means for the control group scores in the pretest and posttest, which was found to be equal to 2.79. Figure 5 below present the comparison between the means difference of both groups.

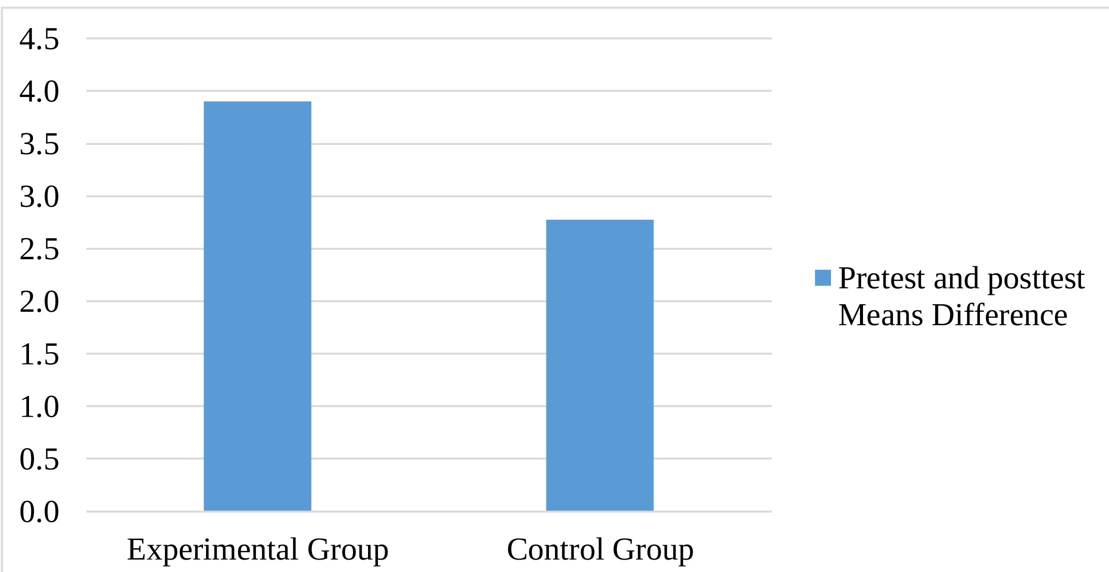

Figure (5): Comparison between means' difference of pretest and posttest scores of experimental and control groups.

Figure 4 shows that the experimental group participated students had a higher scores compared to control groups. Furthermore, the results showed that experimental group standard deviation reduced more than the control group reduced after conducting the experiment, which reflecting that the use of STEM PBL reduced the variation between the experimental group students outcomes. Such results partially address the research question that the academic achievement of the students was significantly improved for both classes who engaged in STEM PBL approach more than the students who did not.

4.1.3 The differences between the control and experimental groups in the posttest scores.

An independent t-test was conducted in order to answer the research question by comparing the posttest scores of the experimental group and control group to assess whether there is a statistically significant impact of STEM PBL approach on elementary students' achievement in science classes or not. The results of the independent t-test are presented in table 4 below. Full analysis is shown in appendix 6.

Table (4): Descriptive statistics and independent T-test results between posttest results of both the experimental and control groups.

Group	**N**	**Mean**	**Std. Deviation**	**t**	**df**	**Sig. (2taile)**
Experimental Group Post-test	55	7.38	1.727	4.142	110	0.000
Control Group Post-test	57	6.07	1.624			

The results shown in table 4 indicated a high statistically significant difference between the experimental and control groups where t (110) = 4.142 with a P value equals to 0.000 < 0.05. In addition, the mean for the experimental group is 7.38 and for the control group was found to be 6.07 as presented in table 4 above. These results revealed that the implementation of STEM PBL approach effected the achievement of the elementary students in science in a positive way compared to Non-STEM approaches.

The study's hypothesis was confirmed, as there was a statistically significant difference in the scores of the elementary students who participated in the experimental group where they learned the energy transformation topic through STEM PBL approach and those who were in the control group where they learned the topic without the use of STEM PBL approach.

4.1.4 Reliability of the study

Test and retest is one way of measuring the reliability of a research tool using correlation coefficient (Johnson 2014). After conducting the posttest and pretest, Pearson correlation factor was calculated in order to indicate the reliability of the test. The results are shown in table 6 below.

Table (5): Pearson correlation factor between the pretest and posttest scores.

Correlations

		Pretest for all students	Posttest for all students
Pretest for all students	Pearson Correlation	1	.813**
	Sig. (2-tailed)		.000
	N	112	112
Posttest for all students	Pearson Correlation	.813**	1
	Sig. (2-tailed)	.000	
	N	112	112

**. Correlation is significant at the 0.01 level (2-tailed).

As shown in figure 6 above there is a strong relation between students' results in the pretest and posttest, which indicate a high reliability of the energy transformation test.

Furthermore, the Cronbach α coefficient was used to evaluate the consistency and reliability of the energy transformation test. Typically, α 0.70 (Nunnally 1967) is the accepted norm to make the scale internally consistent Nonetheless, for newly developed measures, Nunnally suggests a minimum standard of α 0.60. Table 5 below presents the reliability statistics of the current research.

Table (6): Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.896	.897	2

Cronbach's α coefficient for the pretest and posttest was found to be 0.896, which indicates that, the test have high internal consistency.

4.2 Qualitative Results

After conducting the quasi-experiment and collecting the data from both control and experimental groups, face-to-face semi-structured interviews were performed with 10 students from the experimental group. The aim of these interviews is to find deep meaning, solidified and to confirm the results from the quantitative part. The collected data were analyzed using the descriptive method of analysis, which revealed the responses of the participants and presented their quotes illustrating their understanding of the aspects studied. All of the participants those who were interviewed stated that they enjoyed this type of project and they had enhanced their learning. The interviews consisted of 6 questions (see Appendix 1) were the first three questions were centered on the projects they have worked on and the steps they have taken in order to finish their project and whether they have encountered any challenges through the project and how they have overcome them and how their project will help others. Questions 4 and 5 focused on what students think about STEM PBL learning and whether it helped them to understand the subject better than normal teaching methods and to explain how it helped them. In addition, students were asked about the skills they developed after completing their projects. The last question asked the students about their future career, and what they would like to be in the future.

4.2.1 Elementary students' understanding and satisfaction of the STEM PBL approach.

The first three questions focused on measuring participants views of the STEM PBL approach, and to what degree this approach was found to be an effective and enjoyable. The answers from students showed that the PBL process and steps that they have to take to finalize their work have been fully understood. One student said, "**When we did our project, first, we started collecting the information from the internet and YouTube then we wrote our plan and the required materials then we drew our design sketch of our car. After that, we build it and tested it then we started collecting some data like the mass and the time for our boat to travel certain distance, next we analyzed these data and made our conclusion.**

Moreover, students had been able to explain the main goal of their projects and their impact on others. Students ' responses showed that they understood that their projects are related to their real life because they claimed that their innovations can benefit people in various ways. Some of the students' answers are shown below.

"**Our project helps others because it helps in stopping pollution because our car motor does not use fossil fuel instead; it uses alternative sources of energy such as wind."**

"Our boat was amazing and it is important because it uses the sun energy instead of the fossil fuel, which will help in saving the environment from pollution. We had fun doing this project but we faced a problem connecting the wires between the motor and the solar panel."

In addition, students' answers also showed that they liked working as a team in their projects. It made it easier and more enjoyable for them to learn about energy transformation through making these projects. As a result, PBL helped students to develop their communication skills and learned to work as a group. "**Our thermal windmill helped us to understand how thermal energy change to moving energy and we can use this windmill to produce electricity."**

"We faced many problems at the beginning with dividing the work between us but we started to work more as a team as we went through the project."

Furthermore, students shared some of the technical problems they faced while doing the project, how it affected their projects, and how did they solved these problems. The following are quotations from the responses of the students:

“When we did our car the first time we cut the foam in a rectangle shape and made it large which made our car slow. The second time we cut the foam like the triangle shape and made it smaller and our car was faster.”

“When we did our car, we made a mistake by making a big hole in the cab that caused our tires to be loss for the wooden stick and the tires started to shake when the car move so we replaced the caps and we made smaller holes to make it tight and our car went straight.”

Moreover, students demonstrated ability to design, and find alternatives as part of the STEM PBL modeling.

4.2.2 STEM PBL impact on students’ skills.

The forth question asked the students about how the STEM PBL approach affect their understanding of the energy transformation topic and if it better than normal teaching. The aim of this question is to measure if the STEM PPL approach have a positive impact on the elementary students’ comprehension of the scientific concepts. Students’ responses showed that after finishing their projects the students had better understanding of the energy transformation processes. “**Projects are better because when you learn by doing the projects you learn faster than normal things, because when someone come and tell you that solar energy will become electricity you can’t understand it but when you do it and see it you will understand it and it will be easy.”** In addition, after doing their projects students were able understand and connect the impact of the energy transformation applications on the environment. “**Conducting this project was interesting for me and I have learned more about energy transformation by doing this project and how this affect the environment.”** Moreover, results showed that STEM PBL approach helped students to be independent learners by giving them the opportunity to do it by themselves. For example, "**This project was interesting because I did it myself with my group and learned from what I did and it is more interesting than listening to the teacher telling me that without trying it.**"

Students' responses also indicated that STEM PBL approach provided the students the chance to work as groups and develop teamwork skills. For example, "**Learning by doing our project let us to be in a group to finish fast and it is better to work in group instead of working alone and made the topic easier.**"

The aim of the fifth question was to investigate the impact of implementing the STEM PBL approach on developing elementary student skills and equip them with the required skills that they might need in their future such as problem solving, critical thinking, teamwork, self-learning, self-esteem and engineering skills. The following are some examples of the students' answers.

"When we did our boat, I learned how to test things and how to collect different information and data and make calculations."

"When I did my project, I learned about technology skills and how to connect things. Also it helped me to learn how to take measurements like the time needed for our car to move one meter and the mass of our car."

Doing this project when we did the design it helped me to develop my engineering skills and when we did the calculation, I learned to solve mathematics equations."

The last question asked the students after they finish their projects about where do they see themselves working in the future. Some of the students' answers reflected that STEM PBL approach increased a positive interest for students to peruse STEM careers in the future.

“Our solar boat was really cool, it helped me to understand the energy transformation lesson and I would like to be an energy engineer in the future.”

As a summary, the quantitative and qualitative results showed that pupils had positive perspective and perceptions towards the STEM PBL approach in science. In addition, the STEM PBL approach has had a positive impact on students ' comprehension and achievement of science where the scores means in the posttest of the students showed that students had a better achievement in the energy transformation test for the experimental group compared to the controlled group where the means for both groups was 7.38 and 6.07 respectively. In addition, the results showed that there is a statistical difference between the experimental and controlled group's scores means where the independent t-test results showed that t (110) = 4.142 with a P value equals to 0.000 < 0.05. Moreover, qualitative results showed that STEM PBL has made the learning process easy and enjoyable. Furthermore, STEM PBL approach help in equipping students with the essential skills that will prepare them for the workplace in the future.

Based on the quantitative and qualitative results presented in this chapter, these findings are addressed in the light of earlier studies and relevant recommendations are presented in the next chapter.

Chapter 5: Discussion, Conclusion, Recommendations and Limitations

STEM PBL has a major impact on the achievement and motivation of learners. Providing differentiated strategies based on student interests and skills helps evaluate learners with different unique skills. In addition, STEM provides a cooperative working environment for learners, enabling them to develop more expertise in sociocultural and communication. Integrating Science, Math, Engineering, and Technology disciplines in this study showed huge changes to the level of the student. By using the STEM PBL approach, the student has shown improvement in their skills. The idea of curriculum integration enhanced student learning, as it helped them to gain further information that led to a deeper and stronger understanding of the subjects.

This chapter addresses the findings of the study, analyzes them in the context of theoretical framework and earlier studies, provides the conclusion and provides suitable recommendations for further studies and limitations of the study.

5.1 Discussion

The study was conducted at a private American school in the UAE in Sharjah. The students from the 5th grade were the participants. The aim of the study was to investigate the impact of implementing STEM PBL approach on elementary students' academic achievement in science compared to non-STEM PBL instructions in private school in Sharjah, UAE. The study took a period of six weeks in the first term. As mentioned earlier in the chapter three and four, the current study was carried out into two steps: quantitative and qualitative. The results of this study revealed that the current study was consistent with previous studies

The main question of the research was to investigate the impact of STEM PBL on students' achievement. It was hypothesized that there would be a statistically significant difference in the students' academic achievement between the students who were taught using the STEM PBL approach and those who did not. A pretest posttest quasi-experiment was used in this study in order to investigate the impact of STEM PBL on students' achievement. The results showed that the students had a major improvement in their progress through the development of their achievement and the development of their skills where the scores means for the experimental and control groups in the posttest was found to be 7.38 and 6.07 respectively. Additionally it was found that there is a statistical difference in the achievement of the students who were exposed to the STEM PBL in the experimental group compared to the control group where the independent t-test results between the scores means for both groups in the posttest showed that $t(110) = 4.142$ with a P value equals to $0.000 < 0.05$. The findings of the current study indicate that STEM PBL enhances engagement collaboration, interest, understanding, awareness, and skills, which in turn enhances their productivity and achievement as the students clearly stated in the interviews (Lou, Chou, Shih & Chung 2017). In addition, the successful involvement of every pupil, getting them enthusiastic about new and different projects was a significant observed outcome. In the light of several previous studies on the major difference between students learning using STEM PBL and students studying the same content using traditional teaching methods at the same period, it can be found that PBL provides greater self-capability for learning STEM disciplines and increases student achievement compared to Non-STEM education (Bilgin, et al. 2015; Han 2017).

As stated in the literature review and as shown in the results, STEM-PBL has revealed an important effect on students' efficiency. Many researchers have recognized the value of STEM PBL to improve learners ' performance by enhancing their critical thinking (Ejiwale, 2012). Han (2014) claimed that if the learning environment is STEM PBL, student achievement increases significantly. This demonstrates coherence with the findings of the current research. In the STEM education process it is important to integrate the interdisciplinary STEM approach with instructional approaches including PBL, problem-based learning, and inquiry-based learning. (Khalil and Osman 2017).

Through working in groups, students are given additional opportunities to develop different skills such as data analysis, problem solving, critical thinking and communication skills (Baran et al. 2016; Khalil and Osman 2017; Dejarnette 2016). Therefore, it is also possible to accept the ideas of others, to be an effective team member, to be a leader, and to use techniques to solve problems are all made available. As a result, this will increase the quality of education and student's achievement (Sofroniou and Poutos 2016).

There are some explanations why the correlation between STEM-PBL and the student achievement could be relatively good. The most important factor is when the learners begin to combine more knowledge between the disciplines they acquire and develop more skills and knowledge that will help improve their achievement and performance. STEM supports and improves the 21st century's skills which in effect improve students ' success and prepare them for their future careers.

Students' answers in the interviews showed that they considered working in groups to be an interesting part of STEM PBL. Students enjoy working in collaborative student-centered environment where they improve their communication skills, make decisions, and take responsibilities. The positive attitude of students to STEM projects is an interesting part of this research. All of them agreed during the interviews on STEM PBL positive achievement and motivation impacts. Students were satisfied with the cooperative atmosphere. Moreover, the result demonstrates student satisfaction with STEM PBL. During the experiment, students have shown their excitement in working together in groups. This suggested STEM PBL's success as a student-centered approach, through their excitement for STEM subjects (Han, 2015). Han (2015) suggested that students work cooperatively in decision-making groups that are a central driving force in STEM education, group work that influences and enables learners reach social maturity. Tseng et al. (2013) proposed that STEM PBL should be introduced as a key factor in growing student motivation to learn and choose future STEM professions. Smyrnova Trybulska et al. (2016), in their study, emphasizes the need for students to be well prepared with STEM-related skills, especially at the elementary level.

Several factors determine differentiation, which provides each learner with appropriate activity based on their skills and needs (Bilgin, Karakuyu and Ay 2015). Apart from student's cognitive level and their different abilities, the school setting, family, the wider community and the material are all considerations that must be taken into account when planning STEM projects (Capraro et al. 2016). Han et al. (2015) claimed that an optimal approach for meeting the unique academic abilities and desires of each individual and providing opportunities for learners to show their learning in various ways could not be assured. Varieties of teaching and learning practices have to be used in order to improve learners' abilities, and activities need to include entire groups, small groups and individuals. Having this variety of schools raises students ' level of achievement and motivation. Guyotte et al. (2015) concluded that successful teams' formation improved the performance of learners. Han, Capraro and Capraro (2015), on the other hand claimed that STEM PBL affects various learners differently.

PBL encourages learners to improve their skills of the 21st century, such as critical thinking, problem solving, creativity, communication and teamwork, in order to equip them with the required skills for STEM carriers (El Sayary, Forawi and Mansour 2015; Akundi 2017; Edmunds; UAE Vision 2021). In its ability to give real meaning, it includes students more in real life events, and improve student's interdisciplinary skills in the 21st century; this is now recognized as an important learning model. (Drake, 2012). Researchers and curriculum reformers have indicated that incorporation is one means of achieving and satisfying aspirations including those focused in STEM education (Moonesar & Mourtada 2015).

Additionally, the NGSS, part of this study's theoretical framework, outlined measurable performance requirements per each grade, each purpose represents three key aspects of scientific learning: interconnected scientific and engineering practices, and core insights into the discipline for the advancement of students ' skills for the 21st Century (NRC 2012; NSTA 2013). This is directly related to the outcome of the current study in which STEM PBL had a major effect on the skills of the students of the 21st century.

Results from the interviews indicated that most of the participants stated that the STEM PBL approach helped them in developing their 21st-century skills (Han 2017), enabling them, by engagement in real-world activities, to develop their collaboration and communication skills and facilitate real-life solutions. According to Lou et al. (2017), PBL approach increases the motivation of learners in STEM education by means of projects, research, problem solving, practical activities and decision-making (Roberts et al. 2018). In addition, students' responses showed that students had positive understanding reflecting on the effect of STEM PBL on learners' choice of the future career. This indicates that students agreed that STEM PBL approach helps prepare them and improve their participation in potential STEM fields, as well as providing them with a strong basis for selecting STEM fields to pursue in the future (UAE Vision 2030; Stipanovic and Woo 2017). In order to improve STEM education system and the future involvement of students in the STEM programs and careers, it is important to adopt an effective education approaches such as PBL (Akundi 2017; Miller, Sonnert & Sadler 2018).

Moreover, based on the students' answers in the interview it showed that students enjoy STEM PBL type of education and instructions compared to other approaches as it helps develop student interest by collaborating with team members and presents them with a new learning environment (Hwang, Tu & Wang, 2018). These results are aligned with Liu & Chien observations (Lai and Hwang, 2015). Papert, (2000 in Hwang, Tu&wang, 2018) states that the expectations of students to progress to a higher level through this modern educational approach will be dramatized science, which will increase their ability and enthusiasm to know more. In fact, Jonassen & Carr, (2000) claims that learning by design, centered on constructivism, is favored between all the different teaching approaches because it allows learners to think about the key aspects of the content of science in order to deliver it to others in their design. This helps learners to draw on what they know in combination with what they need to develop without constraints (Hwang et al. 2018). Therefore, by managing it themselves, learners may initiate their thoughts and use their work plan or tools. This can also encourage learners to be fully involved as they are actively involved in progressing systematically towards meaningful learning, as well as the successful completion of their design (Minovic et al. 2011). Such findings are also relevant to the theoretical framework of this research, in which positive knowledge and self-development will lead to better outcomes and greater achievements among learners (Pegrum et al. 2015). When improving their understanding students can link with already existing knowledge and new knowledge through the application of critical concept analysis that will allow them to extend their experience and retain their knowledge even longer (Pegrum, Bartle & Longnecker, 2015). For this purpose, students should be active in the learning process to create meaningful learning in science education.

Furthermore, through learning communication skills, learners can consider the views of each other and appreciate the importance of cooperation (Pheeraphan, 2013). Vygotsky (1978) found out that children could develop valuable communication skills by interacting and working with people (Wang et al. 2016). By having the work plans for the project, learners may share ideas and learning interaction to overcome the difficult challenges, they face in order to fulfill their mission (Wang, Huang, & Hwang, 2016). That through interactive learning, students improve their comprehension (Beyhan & Baş, 2010). Thus, this constructivist paradigm demonstrates that learners are active agents in the learning process and gain a better understanding. Therefore, students must develop knowledge and learn it according to their unique way of seeing their world.

The findings of the current study reveal that when implementing the STEM PBL approach, the students overcome several different issues. The same indication was also noted in the Study by Capraro and Sun Yung Han (2015) that the STEM PBL approach improves student achievements, particularly in mathematical skills. However, the present study interviews showed that the participants usually asked themselves a variety of questions that pushed them to explore, collaborate, and communicate to figure out solutions. Furthermore, Han (2015) highlighted the importance of equating the team work through the STEM PBL approach in order to help the learners work together to achieve all the skills of the 21st century. The same finding even occurred in the current study when the students did their projects in groups. In the current study, students learned how to function as a group to help them achieve their goals. The current study findings align with Han (2015) results that the STEM PBL approach needs to be implemented by grouping the learners that revealed positive effects towards the students' achievement of 21st century skills. Learners who are actively involved in cooperative learning will achieve a higher level of achievement compared to other students who learned based on traditional approaches (Slavin, 2014). PBL supports students to improve 21st-century skills such as teamwork, critical thinking, innovation, problem solving and communication to create a well-prepared STEM career generation (Husin et al, 2016; Akundi 2017; El Sayary, Forawi and Mansour 2015).

The findings of the study are promising from a pedagogical viewpoint. This approach is very effective for students with low confidence and motivating skills, or those who need to improve their ability to prove, reasoning, and solve problems. The current study has shown that STEM PBL is an effective approach for improving students' understanding, achievement, and skills.

5.2 Conclusion

The current study was carried out in order to investigate the impact of implementing STEM PBL approach on elementary students' academic achievement in science in the UAE. The mixed method approach was utilized in order to fulfill the current research purpose. In order to collect quantitative data, a pretest posttest quasi-experimental research design was carried out with hundred and twelve grade 5 elementary students in four classes who participated for five weeks in the study from private school in Sharjah that follows the American curriculum. Semi-structured interview was carried out with 10 students from the experimental group in order to collect the qualitative data.

The current study found that STEM PBL approach has a statistically significant positive impact on elementary students' academic achievement in where the independent T-test results were for t (110) = 4.142 with a P value equals to 0.000 < 0.05. Moreover, based on the observation through the experiment and students' responses during the interviews the results showed that students enjoy STEM PBL compared to Non-STEM approaches. The findings of the study revealed that implementing STEM-PBL has a great influence on the learning of the students, and that the students participated in the study expressed a positive attitude towards this approach. Students appreciate the benefits of understanding the subject and linking it with real-life problems as well as with the activities involved.

Students' answers during the interviews indicated that students considered the STEM PBL approach beneficial as it gave them the chance to work and interact with each other, to try and use their expertise to finalize their projects, as well as its positive impact on their skills and achievements (Han, Capraro and Capraro, 2015). In addition, this study showed that applying STEM PBL on elementary students in teaching science helped motivate them and engage them in teamwork. In addition to developing skills such as critical thinking, creativity, problem solving and a deeper understanding and interpretation of scientific knowledge, learners build their own awareness by working with their team members (Hwang et al. 2018). Additionally, learners can practice leadership skills through group guidance, negotiation, and discussion, as well as acquire responsibility and strong self-esteem. Gaining academic and communication skills together will provide learners with the key 21st century.

5.3 Recommendations and Implications

STEM education is widely demanded. Development of STEM education calls for effective strategies and approaches like PBL to be implemented. Based on the results of the research and the associated literature, more research is required in order to enhance the implementation of STEM PBL approach and students' achievement is recommended with the following guidelines. One of the most important reasons for implementing STEM PBL approach is to improve the achievement of the learners and to increase their motivation to peruse STEM professions in the future. The current study measured the impact of STEM PBL approach on elementary students' achievement in science but the study was carried out on grade 5 boys' students. It is recommended in the future to carry out a research to investigate the impact of implementing STEM PBL approach on the learners' motivation and interest. Moreover, the current study did not highlight the challenges that may face the implementation of STEM PBL in the UAE, so it is recommended to carry out a research about these challenges. Admins plays a key role in the implementation of STEM PBL approach studying their perceptions and their contributions and help in the implementing STEM PBL approach is recommended for future studies. While the research sample included elementary school students in American curriculum school, it is recommended to carry more similar studies with middle and high schools that follows different curriculums.

The results of the current study encourage schools to develop their curriculums to be based on STEM PBL approach as it has a great influence on students' academic achievement and skills development. Moreover, teachers are the key factor for the success of the implementation of STEM PBL approach; the current study results guide the teachers to implement this approach frequently in order to improve their students' academic achievement.

5.4 Limitations

Although current study showed that STEM PBL approach has a significant effect on grade 5 five students' academic achievement in science classes but it had some limitations. The first limit is the number of participants, and an increase in the number of participants provides more reliable results. Moreover, the participants are only grade five students from one American curriculum school in Sharjah. Including different elementary grade levels from different schools with different curriculums from different emirates will help to generalize the results of the study. In addition, the research was conducted on one strand of the science curriculum, which limits the findings of the study. Finally, Because of this study's quasi-experimental nature, concerns to internal and external validity that need to be addressed. Since the participants were already in groups (classes), sampling randomization was restricted to intact (class) random sampling, rather than individual random sampling.

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Appendices

Appendix 1

Interview Questions:

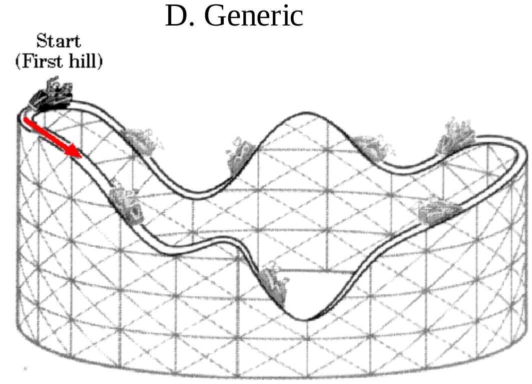
1- What was the project that you worked on with your group?
2- How can your invention help people?
3- What steps you went through your project? Did you face any problems or difficulties? How did you solve it?
4- Do you think that STEM PBL helped you to understand the topic better than normal teaching methods? How?
5- After completing your task, what skills do you think you have developed?
6- Where do you see yourself working in the future?

Appendix 2

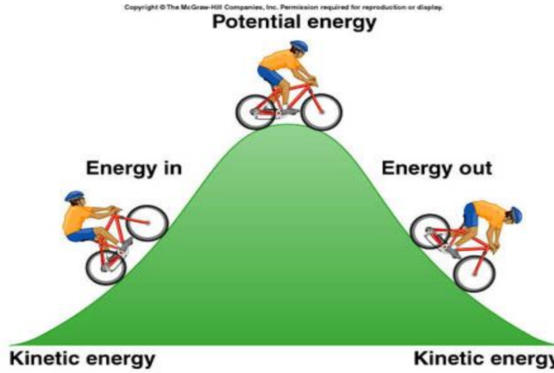
Energy Transformation Test

Choose the letter of the best answer:

1. Energy is _____.
   A. is the ability to do work or cause a change
   B. is all the movement in the universe
   C. cannot be created or destroyed
   D. all of the above
2. Energy forms can be ____.
   A. Chemical   B. Thermal   c. electrical   d. Kinetic   e. All of them
3. The law of conservation states: ___.
   A. Energy can be created and destroyed.
   B. Energy is never created nor destroyed.
   C. What goes up must come down.
   D. Electrical energy can be transformed into other forms.
4. _____ cars use an electric motor as well as a gasoline engine.
   A. Electric   B. Mechanical   C. Hybrid   D. Generic



5. Where is the potential energy greatest?
   A. At the dip two cars past the red arrow.
   B. As the car is moving up the hill 3 cars past the red arrow.
   C. At the top of the hill before the red arrow.
   D. There is no example of potential energy.



6. Where is the kinetic energy GREATEST?
   A. As the biker is climbing the hill.
   B. As the biker is at the top of the hill.
   C. As the biker is on the downside of the hill.
   D. There is no example of kinetic energy.

7. __________ is energy stored by things that stretch or compress.

A. Elastic potential energy

B. Chemical kinetic energy

C. Elastic kinetic energy

D. Gravitational potential

8. Friction can create _______.

A. Thermal energy

B. Kinetic energy

C. Nuclear energy

D. Electrical energy

9. What is it called when one form of energy is changed to another form?

A. Energy conservation

B. Energy transformation

C. Electric change

D. Force change

10. What kind of energy are you taking in when eating food?

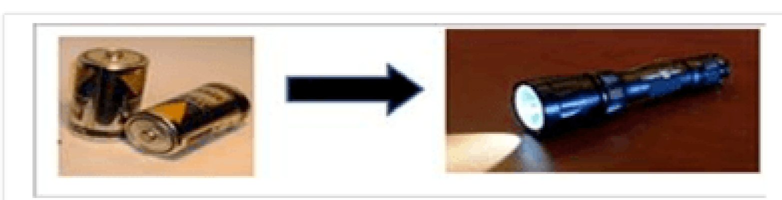
A. Thermal

B. Chemical

C. Light

D. Electrical

11. What energy transformation occurs in the flashlight below when it is on?



A. heat-->magnetic-->light

B. chemical-->magnetic-->light

C. chemical-->electrical-->light

D. mechanical-->electrical-->light

Appendix 3

Consent Form

The British University in Dubai
www.buid.ac.ae

October 2019

To Whom It May Concern,

I am a Masters student in the British University in Dubai BUID since 2017. I am conducting a research study about the impact of STEM Project Based Learning on elementary students' achievement.

The purpose of this letter is to take permission from your school(s) to conduct my study in your educational organization in the academic year 2019/2020. This study requires implementation of STEM PBL in selected classes in elementary school, and interviews with selected STEM students. The study will take 4 weeks where students will be involved in different STEM projects.

All collected data will remain confidential and will be used only for this research. Participating in this study is completely voluntary. You may discontinue your participation in this study any time. If you have any enquires about this research, feel free to contact me, or the director of the study supervision: Prof. Sufian Forawi. Thank you for your cooperation in this academic endeavour.

Best Regards,

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Appendix 4

4.1 Students’ Scores in the Pretest

	Control Group		Experimental Group	
# of Participants	**Class A**	**Class B**	**Class C**	**Class D**
1	3	4	3	4
2	2	5	0	2
3	0	1	1	3
4	3	1	4	0
5	3	6	4	7
6	4	5	2	1
7	7	6	3	8
8	3	2	8	4
9	1	4	7	0
10	0	3	6	1
11	3	7	4	0
12	4	6	3	3
13	1	7	2	4
14	2	6	2	2
15	2	3	6	6
16	4	4	1	4
17	3	5	2	3
18	2	5	6	4
19	2	2	5	2
20	4	2	3	3
21	4	2	2	4
22	2	5	6	5
23	2	5	5	6
24	2	2	2	4
25	4	2	2	0
26	6	3	3	5
27	2	2	5	4
28	5	3		5
29	2			

4.2 Students' Scores in the Posttest

	Control Group		Experimental Group	
# of Participants	**Class A**	**Class B**	**Class C**	**Class D**
1	7	6	7	8
2	6	6	4	6
3	3	3	5	5
4	7	4	8	6
5	6	8	7	10
6	8	8	6	6
7	9	7	7	11
8	4	5	10	8
9	3	6	11	5
10	4	5	10	6
11	6	9	7	6
12	7	8	8	9
13	4	8	5	7
14	5	9	6	6
15	5	5	9	10
16	7	6	5	9
17	8	7	6	7
18	5	7	8	6
19	6	4	9	8
20	8	5	7	8
21	7	5	5	7
22	6	7	9	9
23	6	6	9	9
24	5	6	5	8
25	8	4	7	6
26	9	5	6	9
27	5	4	9	7
28	8	6		9
29	5			

Appendix 5

Differences between pretest and post-test results for the experimental and control groups.

Paired T-test Analysis.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Experimental Group Post-test	7.38	55	1.727	.233
	Experimental Group Pre-test	3.47	55	2.062	.278
Pair 2	Control Group Post-test	6.07	57	1.624	.215
	Control Group Pre-test	3.28	57	1.820	.241

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Experimental Group Post-test & Experimental Group Pre-test	55	.130	.343
Pair 2	Control Group Post-test & Control Group Pre-test	57	.174	.194

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Experimental Group	Experimental Group Post-test - Experimental Group Pre-test	3.909	2.511	.339	3.230	4.588	11.544	54	.000
Control Group	Control Group Post-test - Control Group Pre-test	2.789	2.218	.294	2.201	3.378	9.495	56	.000

Appendix 6

The differences between the control and experimental groups in the posttest scores.

Independent T-test Analysis.

Group Statistics

	Experimental and Control Groups	N	Mean	Std. Deviation	Std. Error Mean
Post-test	Experimental Group	55	7.38	1.727	.233
	Control Group	57	6.07	1.624	.215

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Post-test	Equal variances assumed	.830	.364	4.142	110	.000	1.312	.317	.684	1.939
	Equal variances not assumed			4.138	108.973	.000	1.312	.317	.683	1.940

Appendix 7

Samples of students' work.