



**The impact of STEM project-based learning on the
achievement of high school students in UAE
(science, technology, engineering, and mathematics)**

دراسة لتقصي الآثار الناتجة على تطور أداء الطلبة في المرحلة العليا
(بدولة الامارات بعد عمل مشروع مدرسي بطريقة ستيم)

by

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of the requirements for the degree of
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Abstract

Achieving an effective learning can be achieved by improving the cognitive and scientific skills for the students. STEM (Science technology engineering and mathematics) revealed a wide range of improving student's cognitive and scientific skills. For example, Robert M. Caoraro, Mary Margaret Capraro and James R. Morgan emphasized that STEM PBL helps the students to know how to solve problems. They refer that to the nature of STEM strategy as it describes as an ill-defined task with a clear and complete outcome. This way of thinking improves the student's cognitive behavior. This improvement because, STEM depends on using problem-based learning to increase literacy by developing the problem solving strategies and the disciplinary knowledge bases. The purpose of the study was to foster the learning through STEM to enhance the students learning by developing their 21st skills, the critical thinking, creativity, collaboration, communication, and the problem solving. In order that the significance of this research is : 1)TO investigate the effects of using STEM -PBL in learning by focusing on the 21st century skills.2)To encourage the students for STEM subjects to be used in learning.3)Meet the United Arab Emirates 2021 agenda to improve the education. This study focus on a higher grades students from grade 9 to 12 boys and girls, ages 14 to 17. So it's aimed to be for the both genders.

The study occurred in United Arab Emirates, Al Ain city. The students who participated in this study they also participated in two researches had done on 2017 and there were about STEM. The current study follows a mixed-method design by using different tools:

1) A student's questionnaire with open and closed ended questions. 2) Student's interviews were also used to collect more data. 3) Evaluating the student's developments qualitatively by using rubric through the whole project.4) In addition, a quantitative method was used by analyzing the student's questionnaires.5) A prototype of rover was also used to as an important tools to reveal the impacts of STEM-project based learning on the students achievements by developing their 21st century skills. The current study elaborate the effectiveness of STEM-PBL on learning by revealing a vastly and great interest toward the using of STEM-PBL by students.

Keywords: STEM-PBL, prototype, and collaboration.

المخلص:

كما هو معلوم لدى الكثير من التربويين ان التعلم الصحيح يمكن تحقيقه عن طريق تحسين المهارات العلمية والمعرفية لدى الطلاب. وطريقة (ستيم) والتي تستهدف الربط بين العلوم و الرياضيات و الهندسة و التكنولوجيا اثبتت نجاحها في الكثير من الابحاث التي اكدت فعاليتها في التعلم. يرجع سبب نجاح هذه الطريقة في التعلم الى اعتمادها على التعلم بطريقة حل المشكلات والتي تزيد المعرفة عن طريق البحث لحل المشكلة. الغرض من هذه الدراسة هو تعزيز التعلم بطريقة (ستيم) لتحسين مهارات القرن 21 لدى الطلاب مثل التفكير الناقد و الابداع والتعاون والتواصل وحل المشكلات. لذلك اهداف هذا البحث تتمثل في: 1-البحث عن اثار استخدام طريقة عمل المشروع بطريقة (ستيم) على التعلم بالتركيز على مهارات القرن 21. 2-لتحفيز الطلاب على استخدام طريقة (ستيم) في التعليم. 3-لتحقيق رؤية دولة الامارات العربية المتحدة لعام 2021 لتطوير التعليم في الامارات. هذه الدراسة تركز على الصفوف العليا من الصف التاسع الى الثاني عشر اولاد وبنات للاعمار 14 الى 17. هذه الدراسة تمت في الامارات في مدينة العين . الطلاب المشاركون كانوا قد شاركوا في السنة السابقة في دراسة عن (ستيم) ايضا. هذه الدراسة تتبع طريقة البحث الثنائي الكمي والكيفي. هذه الطريقة يستخدم فيها طريقة الاستبيان والمقابلات للوصول الى المعلومات و تحليل النتائج ومن ثم الوصول الى النتيجة. كما اعتمدت هذه الدراسة على تحفيز الطلاب بعمل مجسم لمركبة للكشف عن احتمالية المعيشة في كوكب المريخ . وكان من شروط هذه المركبة ان تنفذ بالاعتماد على طريقة (ستيم).

ستيم, مجسم المركبة, الدافعية, الفروق الفردية, الانجاز, التحليل :الكلمات والعبارات الرئيسية
الناقد,التقييم والتقويم و حل المشكلات

Dedication

In my point of view any great work couldn't be completely achieved individually. Likewise, my dissertation is a kind of challenge which is achieved by the helping of my mother, wife, and one friend. So, I dedicate my research to my mother who is always encouraging me. In addition, my wife who supporting me from the beginning to the end. My wife always was like away which is guiding me to move forward. Furthermore, my friend who helped me while doing the analysis. Finally I will not forget the teachers and administrators who helped me for distributing and collecting data from the students. So many thanks for all of these supporters.

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Chapter 1- Introduction

Background

STEM-PBL (Science, Technology, Engineering, and Mathematics) (Project based learning) being payed close attention from a lot of schools these days in UAE and in many other countries which looking for a very good and effective education. A lot of researches provide indications to ensure the effectiveness, validation, and importance of STEM PBL in education. For example, Robert M, Capraro, and Scott W. Sloough (2013) revealed that STEM PBL power science, technology, engineering, and mathematics concepts and making it meaningful. Furthermore, they emphasized that STEM.PBL enhances the 21st century skills like critical thinking, collaboration, peer communication, independent learning, and the problem solving. The usefulness of encouraging students to make a design through which the students make the STEM-PBL to solve the real world problems and use all the 21st century skills affirmed by many previous studies for example, R. Charles Dershimer Joseph Krajcik Ronald W. Marx Rachel Mamlok NaamanA study by b(2004) revealed the positive results for using STEM-PBL by designing a vehicle by which the students use the scientific knowledge to solve a real world problems. The current study also emphasizes the usefulness of using STEM-PBL by informing the students to design a rover to land and discover the mars planet.

Also T Tati H Firmnal and R Riandil(2017) confirmed that STEM-PBL is effective for the future learning. They examined the effectiveness of STEM-PBL by encouraging the students to design a model of boat through which the students use the STEM literacy. The response was positive toward the learning through STEM-PBL.

STEM -project based learning becomes now the aim of many ministries in several countries to attain a good learning. STEM-BPL becomes not a new strategy in learning; however, the new is how to ensure on STEM learning to link between the post-secondary practices and the secondary education. Why STEM, is a question asked long time ago to find out its effectiveness.

For example, it encourages deducing the solutions for any problem which in turn help for an effective learning. Following this kind of learning boost the students to explain their solutions. Moreover, to find the solution the students must do an enormous effort by which they must search, try, and integrate between different subjects and information. The using of STEM-PBL changes the concept of problem solving which was used only in mathematics and it pays the attention toward the learning by solving the problems. Another reason for why the STEM-PBL is preferred is the developing of critical thinking processes by which the students will be ready for the post-secondary practices. Capraro (2013) claimed that student's potential can be increased by STEM -BPL which is discussed and explained in the current paper. He also affirmed how STEM-PBL is useful for future careers by applying that on the real word application; similarly this paper depends on a clear real word application

by which the students start to integrate subjects to find solutions for a real world problem.

STEM-BBL is chosen in this study because as demonstrated by Capraro (2013), it challenges and motivates the students; in addition it depends on collaboration between the students which leads to the communication. STEM-PBL also preferred to be studied in this paper to lead to higher-order thinking skills which in turn assess the future careers.

Significance of the study

The importance of this paper rely on helping the students to identify the problem and determine the constraints, analyze and research the ideas by which the students can explore the solutions, then the students extend their work by building a new idea and communicate to find the best solution, and finally the students used to test, refine, and reflect to evaluate their work. During the work the students always used to integrate between subjects by following the STEM-PBL. Recently, many researches have shown an increased interest in STEM-project based learning to find its impacts on the students learning. For example, the idea of integration of technology in United Arab Emirates schools had been applied in classrooms after obtaining the teacher's perceptions such as Almekhlafi, A. G., and Almeqdadi, F. A. (2010).

Students and different genders.2) the agenda of United Arab Emirates and its aim to explore Mars planet. The UAE agenda aimed to create and send a rover to discover the capability of life in Mars planet. The agenda aiming also to achieve this target by 2021. UAE already starts to create different kinds of rovers and make a competition to encourage the people's creativity.

The main purpose of the study is to foster the learning through STEM to enhance the students learning by developing their 21st skills like the

critical thinking, creativity, collaboration, communication, and the problem solving. In order that the questions of this research are: 1) TO investigate the effects of using STEM -PBL in learning by focusing on the 21st century skills.2) to encourage the students for STEM subjects to be used in learning.3) Meet the United Arab Emirates 2021 agenda to improve the education.

This study focus on a higher grades students from grade 9 to 12 boys and girls, ages 14 to 17. So it's aimed to be for the both genders. The study occurred in United Arab Emirates, Al Ain city. The students who participated in this study they also participated in two researches had done on 2017 and there were about STEM. The results of the previous researches revealed the positive attitudes and perceptions about the effectiveness and usefulness of studying by using STEM. The implicit and explicit ways were used in the previous researches about STEM. This study established due to two reasons. 1) The positive results about STEM in the previous studies for the same target.2) To encourage the students and help the students to use this strategy.

Some limitation faced this study, for example, the resources were not enough or it should be more than the resources used in this study. Also, it would be better if the students get more than three months to do there project to help them to read more and give more chance for the innovation. Another limitation is the number of the teachers which participate in this study.

Scope of work

The study achieved in many steps. Starting by making a work shop for the teachers to inform them with the aim, objectives, methods, and the information. Secondly some class teachers explain to the students the objectives of the project and the criteria of evaluating their works. Then a questionnaire and interviews before they starting the project, after that the students starts to do their works in groups and writing a report for each step individually. Finally a questionnaire and interviews are used again to find the results and the conclusion. Teachers, administrators, and students are involved in this study which helps for encouraging the students and make a climate of using STEM-PBL .Girls and boys participated in this project. One hour is specified weekly through three months working. Students are informed to design a rover can land on mars planet. The rover should be with people inside it which didn't happen till now.

Furthermore, the students informed to use math, science, engineer, and technology to design that rover. Students start by studying the nature of mars planet to find out the problems and deal with the solution to overcome difficulties. Students also informed to report their works and make files. Administrator and teachers helped the students by preparing labs and justify a special time table and to guide the students for any question. A questionnaire is used in this study before and after the project. In addition, interviews are also having done to get more information and to help for analyzing the data.

Aim of the study

This dissertation study purpose is to investigate the impact of STEM project-based learning by developing a rover prototype on high school students' achievements of a high grades students in UAE. In particular, the study attempted to answer the following two questions: 1-What is the impact of STEM PBL rover development on high school student's achievement? 2-What if any differences on high school students' demographics based on STEM PBL rover development?

Based on Capraro (2013) STEM-PBL is defined as follow: An ill-defined task within a well-defined outcome situated with a contextually rich task requiring students to solve several problems which when considered in their entirety showcase student mastery of several concepts of various STEM subjects.

Rationale

The current research has been conducted for five main reasons: 1)as I am working as a teacher, I always has a passion to be In contact with the best learning.2) Also I become interested to do this research after reading many relative researches.3)All researches which I read about the current topic revealed a positive results on learning which encouraged me to so.4)While the most important factor is my experience with a previous researches of the same topic which had driven this research.5) It is a personal and a fieldwork interests. Therefore, this study makes an important contribution to the field of education. The project used in this research provided an important opportunity to advance the understanding of STEM-PBL and clarify its importance for enhancing the student's learning.

Structure for the dissertation

The overall structure of the study takes the form of six chapters, including this introductory chapter. Chapter one includes: background, importance of the topic, brief synopsis of the relevant literature, indicating a problem, knowledge gap in the study, desirability of the study, research questions, a synopsis of the research methods, explaining the significance of the study, defining certain key terms, providing an overview for the dissertation structure, and explaining the reasons for the interest for the topic.

While chapter two involved: General descriptions of the relevant literature, General reference to previous research or scholarship, Reference to current state of knowledge, and Reference to single investigations in the past. Chapter three reveals Describing previously used methods, giving reasons why a particular method was adopted or rejected, Indicating a specific method, describing the characteristics of the sample, Indicating reasons for sample characteristics, Describing the process, instruments used in this study, giving detailed information, and indicating limitation.

Chapter four of analysis includes: Reference to aim, Highlighting significant data in a table or chart, Statements of positive result, Statements of negative result, Highlighting, significant, interesting or surprising results, Reporting a reaction, Reporting results from questionnaires and interviews, Observations about qualitative data, Summary and transition. Chapter five has: Reference to aim, Highlighting, significant data in a table or chart, Statements of positive result, Statements of negative result, Highlighting significant, interesting or surprising results, Reporting a reaction, Reporting results from

questionnaires and interviews, Observations about qualitative data, Summary and transition, Background information: reference to literature or to research , Statements of result, Unexpected outcome, Reference to previous research support, Reference to previous research: contradict, Explanations for results, Advising cautious interpretation, Suggesting general hypotheses, Noting implications, Commenting on findings, and Suggestions for future work.

Chapter 2 Literature review

A large and growing body of literature has investigated how the STEM project based learning effect the student learning and to foster the students to study by this strategy which in turn will improve the student's 21st century skills. In this chapter a major amount of the literature is notarized and reviewed to confirm the effectiveness of STEM-project based learning, The reasons of choosing STEM subjects, the relation between STEM and the problem based learning, the role of STEM on enhancing the 21st century skills, the relation between problem based learning and project based learning, and the effects of STEM on the students achievements.

2.0 Conceptual Framework

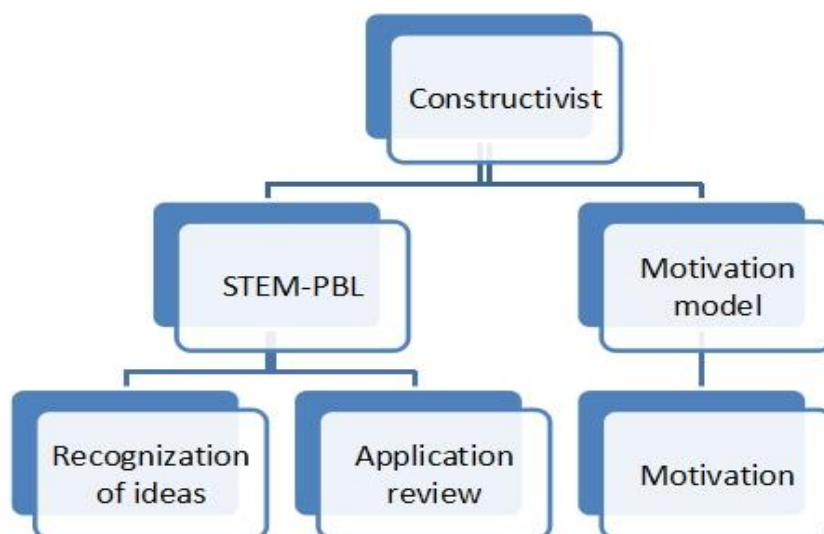
There an unambiguous relationship between the STEM projects based learning and the theoretical frame work which has been used in this study. Theory of constructivist is interrelated to STEM-PBL and the 21st century skills to construct the current study. According to Constructivist theories of learning, each individual learner must make their own information by discovering and modify the complex information. (2nd half of 20th Century).In addition, constructivist suggested that learners seek for the new information then compare it with the old information.

Learners also should be active and teaching be student-centered instruction. Furthermore, constructivist believes that learners should construct and reconstruct their own knowledge and understanding (Frank, Lavy & Elata, 2003).

Constructivist appears also in this study when the STEM -project based learning becomes interpretive which construct the knowledge from society. IN constructivist paradigm researcher is always trying to interpret the complex problems of experience from the point of view of anyone live in that lived experience (Schwandt, 1994).

In the light of the study's purpose, the motivational model of constructivist - informed teaching Palmer, D. (2005) and model of Banet & Nunez (1997) : the three phases model (motivation, then reorganization of ideas and application review)guide this research. So, the following figure shows how theories are interrelated to produce the current study.

Figure 1: title....Conceptual Model of the Study



Effectiveness of STEM PBL

There is a large volume of published studies describing the role of STEM -Project based learning on the students learning and several other studies confirmed the positive perception of teachers towards the STEM-project based learning. On the other hand, other several studies also ensure the positive attitudes and perceptions of the students toward the STEM-project based learning. For example, a study of Tseng, Kuo-Hung, International journal of technology and design education (2013) had done on more than 100 students by doing survey and questionnaire to find out the positive agreement and attitudes toward the learning by this strategy. The study also confirmed that the student's levels improved after studying by STEM subjects.

A study of on Guzey, S. Selcen¹Harwell, Michael²Moore, Tamara¹(2014) book revealed a general agreement, however the book has some limitation, for example the study confirmed the effectiveness of using STEM-PBL but without enough practical evidence to ensure the results got it by this study. The lack of student's perception would be preferred in this study to support the results of this study. There are no questionnaires in this study.

Almost every paper that has been written on STEM includes a section to relate between STEM education and the future career. In the same vein Mackinnon, Lachlan Author Information; Graven, Olaf Hallan; Bacon, Liz_(2015) notes that STEM subjects enhanced the students skills for their future careers. The project had done by using online sites by which the users played a game and using models to make scenarios to achieve their projects. One of the advantages of this game that it distributed through the world especially through many schools networks. This distribution

increases the communication and the collaboration which in turn enhances the 21st century skills for the students and helps them for their futures.

The STEM strategy is activated and become valuable when the students make scenarios to produce their own catalog, then publishing that to a network by which the project's information is distributed throughout the world. Distribution of STEM idea increases the possibility of getting more information and improving the educational skills. Overall the idea use in this study is very good, but it needs a continuous follow up to achieve all the objects. So it is a good idea to distribute and share the idea throughout the world instead of applying the idea in schools because by this way the ideas can be shared easily. In addition, it is very interesting for the students and also effective when the students do their projects by using a game which facilitates the gaining of knowledge. The idea used here is awesome, because it supports the using of technology which already a part of STEM.

A comparative study has done by Guzey, S. Selcen¹Harwell, Michael²Moore, Tamara¹(2014) point at the positive perception of students toward the effectiveness and importance of STEM-PBL for their future. The study was effective because it had done on 785 Korean students in a middle grades. The also confirm what has achieved in the current study that STEM-PBL develop the students' performance. Few limitations appeared in this study that it would be more valuable if it explains the real ability of the students toward the styles of the priority of the learning.

Lou, Shi Jer(2011) examined the impacts of STEM-Project based learning on the student's achievements like the current study but by presenting a practical task by doing experiment. The experiment is about producing speakers by using the process of STEM-PBL. Questionnaires were used in both studies. The Lou, Shi Jer(2011) research had done on 84 while in the current study depends on more than 100 students. Depending in both studies, the concept of STEM-PBL revealed a positive effect on the students learning which confirms the effectiveness of STEM subjects. Similarities appear when both studies had done on high school students. On the other hand the difference appears when the current study informed to produce a rover while in the study of Lou, Shi Jer (2011) the students informed to produce a speakers. Moreover, both studies similar to each other when a questionnaires and interviews were used in each study. Both researches also depend on a continuous feedback to get the advantages and the disadvantages after each step.

The analysis of Korganci, Nuri; Miron, Cristina; Dafinei, Adrian; Antohe, Stefan(2016) study in the International Scientific Conference eLearning and Software for Education identifies the positive effects of STEM-PBL on the student's leaning. Similarities revealed in 1) the number of students used in each study which is almost close to each other (127 and 115 students).2) Secondary school students are used in both studies.3) Questionnaires had been used in each study. Importance and effectiveness of the STEM-Project based learning appears in study of Korganci, Nuri; Miron, Cristina; Dafinei, Adrian; Antohe, Stefan(2016) when the students tried to produce a solar cells at different temperatures depending on math, science, technology, and engineering. On the other side the current study depends on producing a rover to discover the mars planet to obtain the positive perceptions for the STEM-PBL. Agreements

by the students have gained in both researches and the open ended questions have been also used in both researches.

Above all things the students confirmed I their interviews that STEM project-based learning increased their knowledge and prevent the misconception. There seems to be general agreement on Korganci, Nuri; Miron, Cristina; Dafinei, Adrian; Antohe, Stefan(2016) because the target achieved as the students tried to do the project by using STEM-based learning project. The number of students participated in this study is acceptable.

Han, Sun Young_(2014) provided in depth analysis and using enormous number of students of a Korean middle grades. About 785 students were participated in this study from 5 schools. The large number of the students and the variety in schools support the results of this study and confirm the authority for this study. The questionnaires were used to confirm the effectiveness of STEM-PBL for the future careers.

Unlike the study of Han, SunYoung(2014) and Guzey, S. Selcen1Harwell, Michael2Moore, Tamara1(2014) , the findings of Mackinnon, Lachlan Author Information; Graven, Olaf Hallan; Bacon, Liz (2015) seems to be more comprehensive because the communication and the collaboration between students noticed more when the STEM project spread through the world and through a game. So it is clear that when the range of the study increased the possibility of improving the 21st century skills will be increased also.

Another study by Lou, Shi Jer(2011) highlights on the positive and effective feedback of STEM-Project based learning on the students learning. The finding of this research is clear and suitable for other

researches but a limitation appears when the results of the student's perception were inaccurate. So no analysis or percentages were used to reveal the degree and the value of the results got it in the study.

In contrast to Lou, Shi Jer(2011),and Han, Sun Young(2014), Korganci, Nuri; Miron, Cristina; Dafinei, Adrian; Antohe, Stefan(2016) confirmed the usefulness of implementing STEM project based learning and point out to its effectiveness when it applies on the group works. Similarly, the current study concluded that all the students' attitudes were positive toward the new project of STEM. The critical analysis of this study demonstrates the positive student's perception of the usefulness of STEM-PBL, but it would be better if the study had questionnaires which facilitate the gaining of accurate results. The number of students in this study also seems to be not enough to conclude and get accurate results.

WHY STEM?

Nowadays, several studies pay the attention to STEM (Science, Technology, Engineering, and Mathematics) to affirm the positive effect of using STEM on learning and to clarify its effects on the student's future careers. Some researches focusing on the effects of STEM and other studies pay the attention to the STEM-project based learning. The current paper focus on the STEM-project based learning to investigate its effect on the students learning especially on their 21st century skills.

ITEA/ITEEA, 2009 defined STEM by the terms (science, technology, engineering, and mathematics). Then, STEM (science, technology, engineering, and math) defined according to Ejiwale, J. (2012). Facilitating Teaching and Learning across STEM Fields. *Journal of STEM Education*, 13, 3. p. 87-94 as the connection between the learning academic concepts with the real world by applying the integrating approach of mathematics, science, engineering, and technology. It has also been demonstrated that STEM is a fluid study and demonstrated as one process by which the teachers learn the students by integrating the technology, science, mathematics, and engineering as one subject (Merrill, 2009). So, ITEA/ITEEA, 2009, Ejiwale, J. (2012), and (Merrill, 2009) defined the STEM and revealed the importance of integrating the science, mathematics, engineering, and technology for developing the high-order thinking skills to improve learning.

As the integration between subject revealed a positive effect on learning, more subjects added to STEM such as the STEAM when the STEM coupled with art to improve the integration between the subjects and make the learning more attractive (Gaskin, 2014).

Ejiwale, J. (2012) carried out a number of investigations about STEM education like: STEM help the students for their future in their careers (Nano science..), It also help the students to be creative, the students are guided by a facilitator for their learning, teaching by using STEM encourage the students to work collaboratively, the students participate very active in their learning, the learning also connected to real world by STEM, and STEM help students to face the problems and try to solve them contentiously.

The importance of STEM subjects ensures also when Kristy M. Meyrick, (2011) has examined the effectiveness of STEM in learning by comparing between STEM and the old and traditional way of teaching. The comparison depends on the STEM aspects. The study reveals that all aspects of STEM subjects and the student's 21st century skills have improved. Overall the study was valuable, but its limitation appears when the ability of the students toward the learning priority styles was not demonstrated.

A number of studies relate the STEM subjects to the skills of the 21st century skills for example a study of (Rockland et al., 2010, p. 59) found that STEM helps the students to know how to solve the problems. The study found also that STEM helps the students to think deeply for the topics of their interest. In addition the study ensures that STEM facilitates the students understanding. Another example for the effect of STEM on the 21st century skills is the study of (U. S. Department of Labor, 2005) which found that all jobs related to engineering, science, technology, and mathematics (STEM) have been grown to 22% between 2004 and 2014. Similarly, Marulcu and Sungur (2012), Katehi, Pearson, & Peder, 2009 cited in Sungur Gul & Marulcu, 2014) point at the effects of STEM subjects on developing the student's 21st century skills, especially the creativity and the social thinking skills.

Together these studies provide important insight into the effectiveness and the positive attitudes toward the using of STEM subjects. For example, referring to the findings of S. Selcen Guzey¹ Tamara J. Moore² Michael Harwell³ Mario Moreno³ (2016) the students learning enhanced after implementing the STEM subject. Wendell and Rogers 2013,(Bottoms and Uhn 2007; Rethwisch et al. 2012) also demonstrated the same result. The study used many statics and analysis which support the same idea of improving the students learning by the STEM subjects.

The effect of STEM had been investigated by making an action research by Karahan, E., Canbazoglu-Bilici, S., & Unal, A. (2015) after collecting a quantitative and qualitative data to ensure the importance and the value of STEM to enhance the learning.

STEM and PBL

The project which is used in this study depends on the integration between sciences, math, engineering, and technology. The project also depends on the problem based learning process, so the problem based learning is a part of the STEM -project based learning. Ronis, D. (2008) defined the problem based learning as the ambitious to learn in order to gain knowledge. Problem based learning has been involved in this study because as Barrows, H. S. (1986) discussed the problem based learning as a process which depends on the open -ended questions which depends on many right answers, it is also described as a challenging learning, the context of the problem based learning depends on a case or problem instead of question, so the students used to explore, solve the problems in groups, and they tend to be self-directed when they do their job.

Barrows, H. S. (1986) also described the role of the teachers as a facilitator who guide and facilitate the learning and boost the environment of investigation.

STEM PBL has been chosen because as CAPRARO (2103) highlight its importance for : 1)requiring to design for learning by teachers. 2) Integrate the engineering with the subjects. 3) Improving the real world application to enhance the future career. 3) Involving the problem based learning process. 4) In addition STEM PBL relates the secondary education with the practices after the secondary education.5) the students also think critically through the STEM-PBL.

Project base learning described as a well-designed approach involve the students in teaching to explore the authentic problems Blumenfeld et al. (1991).consequently, the students in this research are guided to investigate and solve the problems. The students also in this paper are guided to predict, prepare plans, to debate, write conclusion, ask questions, analyze their data, and communicate their ideas. Blumenfeld et al., 1991 also confirmed the effectiveness of all of the previous activities.

(Lou, Liu, Shih & Tseng, 2011) ensure that PBL tends to evaluate the work depending on reality. So, in this paper the project focused also on reality when the students informed to create a rover for Mars planet. Blumenfeld et al. (1991), (Thomas, 2000), and (Lou, Liu, Shih & Tseng, 2011) Concluded that project based learning is a complex task depends on asking questions and solving problems to involve students in learning by investigation, make decisions, solve problems, and creating products which are authentic and realistic.

Thomas (2000), Middleton (2005), and many other researches confirm that the STEM-project based learning should have the authenticity. The current study takes the permission from the administration to start with this kind of projects. STEM-Project based learning should be authorized from the school to work with it.

CAPRARO (2103) defined the STEM- Project based learning as when students solving many problems and displaying the different concepts by using the all the STEM subjects. The STEM-PBL is described as undetermined task but using a determined outcomes. Based on the Capraro definition the current project used in this study aimed to depend on: solving problems in different ways, using the STEM subjects, determine a specific outcomes, and explaining different concepts.

The study of Guzey, S. Selcen¹Harwell, Michael²Moore, Tamara¹(2014) book revealed the positive feedback of using STEM Project based learning, but some limitations appear when a study uses a few practical analysis to reveal how the learning is improved after using STEM-PBL. In addition, it would be better if the student's perception included in the study by doing interviews and questionnaires.

STEM and 21st century skills

Creativity occurs during problem solving (Guilford, 1967) when it is necessary to discover novel solutions to problems (Cropley, 2001; Guilford & Hoepfner, 1971; Plucker, Beghetto, & Dow, 2004; Reiter-Palmon, Illies, Cross, Buboltz & Nimps, 2009) and to solve complex social problems (Wang, 2012). STEM programs develop higher order skills, e.g. creative problem solving, product building, collaborative team work, design, and critical thinking. Ejiwale, J. (2012).

Overall, the study of Tseng, Kuo-Hung, International journal of technology and design education(2013) highlight the positive attitudes of 100 students after doing a questionnaire and interviews about the effects of STEM -Project based learning on the students learning. The study also emphasizes that the STEM-PBL helps the students to attain their needs for future. The study of Tseng, Kuo-Hung,

(2013) Is like the current study ensures that the STEM-PBL develops the 21st century skills for the students.

Over the past decade most researches in STEM-Project based learning has emphasized the positive impacts of STEM-PBL for example Morgan, James R. Capraro, Mary Margaret Capraro, Robert Michael (2013) revealed that STEM project based learning improve the skills of thinking and solving problems as concluded in the current paper but by focusing on all the 21st century skills.

The current study concluded that the 21st century skills improved by the STEM subjects which indicates the positive effect of STEM on the student's future. This can be noticed when a study in United States revealed that an increase of one million 33% more workers than previously after using STEM fields (Gates & Mir kin, 2012).

This paper focused on the 21st century skills because as concluded by (Lantz, 2009) that the strength in these skills is essential for students for the successive in their global workforce.

(Lantz, 2009) defined the 21st century skills as the real world problem which maintain the competitiveness in the global economy. He also confirmed that constructivist is attained through STEM and the aim of the project based methods is to build an application of knowledge.

Positive attitudes have been noticed in this study as many other studies had the same attitudes toward the STEM-project based learning for example (Robert Michael, Morgan, and R.Capraro, Mary Margaret, 2013) affirm the impacts of STEM –PBL on the students and how it effects on their future career. The authors published a second edition book to reveal the effects of STEM-PBL on the students learning.

The results of this study revealed how STEM become useful for the future career, encourages the communication between the students, improve the critical thinking skills, leads to creativity, leads also to higher –order thinking skills, doesn't depend on memorization, and to define better solutions.

The study of (Robert Michael, Morgan Capraro, Mary Margaret, 2013) seems to be effective, but it would be more accurate if the STEM-Project based learning is applied for more than four days. In spite of the time appears not enough but the students agreed with this kind of projects and they preferred the continuously checking of their work .In addition, the level of discussion between the students increased as concluded also in the current study. One of the most important outcomes of the STEM – Projects based learning which observed in the current study and in study of (Robert Michael, Morgan, R.Capraro, Mary Margaret, 2013) is the transition from teacher driven procedure to the student driven procedure by which the role of students become more effective.

Problem based learning and project based learning:

The current study aims to help the higher grades students to make a project by using the STEM-project based learning approach. The project starts by initiating a problem of how to make a rover which can discover the mars planet. The students were guided to use the STEM -subjects. Consequently, the problem based learning is involved in the STEM-Project based learning. Problem based learning is preferred in this study, because It is defined as cognitive operations to direct the goals (Anderson, 1980).it is also defined as a need of learning to gain knowledge Ronis, D. (2008). The problem based learning has chosen because according to Ronis, D. (2008) : 1)it is started by developing a real world problem which is open ended and with unclear solutions.2)involves skills and different concepts 3)Including tools and resources such as the internet 4)reflection and evaluation have been used in problem based learning.

In the current study the students provided with all resources and strategy of feedback and evaluation has been followed after each task.5)apply on a real life situation 6)discussing, presentation, and writing summary.7)The project based learning follows the problem based learning in the current study also when the students research, hypothesize, plan strategies, and try to find the solution.8)the role of the teacher is to guide the students, provide them by resources, and help keeping them on track. The problem based learning is used in this study because it guides the cognitive activities in the real life as described by (Jonassen, 2000). Several studies confirm that problem based learning is helping the students to be scientists and engineers by solving the problems(National science foundation 1996, Boyer Commission Report, 1998&2002and Engineering and public policy, 2006).Furthermore, the Problem based learning includes many of practices, different strategies, and is ill-structured problem which are followed in the current study (Savery,2006; Jonassen & Hung, 2008; and Graaff &Du 2009). One of the most important reasons which encourage this study to use the problem based learning is that students will be the center and the majority of the learning (Etherington, 2011).

As the learners build their own understanding for the new knowledge when they use the problem based learning strategies so, the constructivist is the theoretical frame work that support the problem based learning. Metacognition and cultural and social factors also support the problem based learning.

The using of problem based learning, the students add more to their experiences (Piaget 1954) which is also has been noticed when the students did their project in this study. The students in the current research interact and collaborate to achieve their job and solve the problem. This collaboration starts from the individual and becomes a part of cognitive development for the students (Vygotsky, 1978).

The purpose of this study is to investigate the impacts of STEM PBL and problem based learning on the development of 21st century skills. This purpose can be achieved by the metacognition which help the students to think about the thinking.

STEM AND STUDENT ACHIEVEMENT

Several studies found that there is an enormous difference between the STEM learning and the traditional teaching methods on the student's achievements. They found that the student's results improved and their capability increased toward learning after teaching them by using STEM subjects (Bilgin, Ay, and Karakuyu 2015).

The current research concluded that the student learning improved after using STEM PBL strategy, also (Nelson et al, 2011) compared between the students average level graduated from STEM- School and the average level of students graduated from a non-STEM school to confirm that the level of those graduated from STEM school had a higher average.

Another study by (Han, 2015) ensures the positive impacts of STEM-PBL on student's achievements when their behavior and attitudes were affected by the sociocultural factors. (Han, 2015) and the results of the current study ensure that the STEM-PBL encourages the students to discuss a lot after achieving any part of the project.

(TSIN, 2012, p.4) revealed that by using STEM students can lead another students which is appeared when a students of Tennessee distribute the STEM knowledge for the nation to show the effect of STEM on improving skills, problem solving, creativity, critical thinking, innovation, and collaboration. The previous skills and practices have been noticed also that they are improved for the students through doing the project in this paper.

Methodology

This chapter is about the research approach methods used to enhance the students learning by developing their 21st skills like the critical thinking, creativity, collaboration, communication, and the problem solving. In order that the objectives of this research are: 1) TO investigate the effects of using STEM -PBL in learning by focusing on the 21st century skills.2) to encourage the students for STEM subjects to be used in learning.3) Meet the United Arab Emirates 2021 agenda to improve the education.

The project aimed to produce a rover prototype which helps to investigate the nature of mars planet. The paper aimed also to find out if the students' demographics (gender and grade level) have any effect on the results. Same conditions and same resources had been used with the participants while doing the project. Grades 9 to 12edit girls and boys students are participated in this study. Interviews and questionnaires are conducted before and after the STEM-Project based learning, then they compared to get up with a results and conclusion.

The instruments used in this research, to explain how data were collected, piloting of instrument, and the instrument administered. Type of data analysis; issues and reasons are also clarified in this chapter. The current research hypothesized that about 95% of the students which will

participate in this study be interested and will notice the differences from the previous projects. This hypothesis built on 3 researches and it had done before with the same students by using STEM in different ways.

Also many researches confirm that STEM subjects don't depend on memorization, cooperative process but it depends on using technology which is always preferred by students.

Research approach

A mixed method approach has been chosen in this study to investigate the impacts of Stem Project Based Learning by producing a rover prototype on the achievements of a high grade school students, boys and girls in the UAE. Mixed methods involve the integration between the quantitative and the qualitative methods in the research study. This integration had been described by (Greene, Caracelli, & Graham, 1989). This methods has been chosen because it facilitates the understanding of research problems than using only one of other methods (Creswell, 2005) . A conceptual frame work has been used in this study.

The mixed method used in this study is called convergent parallel mixed methods. In convergent parallel mixed methods the investigators collect both forms of data at the same time then combine the information in the interpretation of overall results (John w creswell, 2014).This mixed approach is used also to explore how the STEM -BPL effects the students achievement, to find how STEM can be valuable and the differences in the gender perceptions (Tilchin and Raiyn, 2016, Hathcock, 2015, and Han, 2013).

Creswell, John W. (2014) explained the main characteristics of the mixed research methods which are used in this study. Creswell describes this method as an emerging and predetermined methods, has open ended and close ended questions, on all possibilities it contains several forms of data drawing, it is also has statistical and text analysis, and it has across databases interpretation. Creswell (2014) also describe the mixed method as a pragmatic knowledge claims, sequential, concurrent, and transformative. Mixed research method also helps the researchers to attain more data and results than the qualitative or the quantitative methods, in addition the mixed method helps for covering more topics as suggested by Johnson and Christensen (2012).

Sampling and participants

This study managed in 3 steps: step 1 is to make interviews and distribute a questionnaires for the students before starting with the STEM project based learning to ask them about the project which they used to do. At the same time the interviews are also used with some teachers who supervising the projects. Step 2 is to make interviews and use another questionnaire for the student after doing their project which help for appearing any motivation or achievements (Muller 2015). Step 3 is to compare between the questionnaires and interviews before and after doing the STEM – The following figure shows the steps of data collection

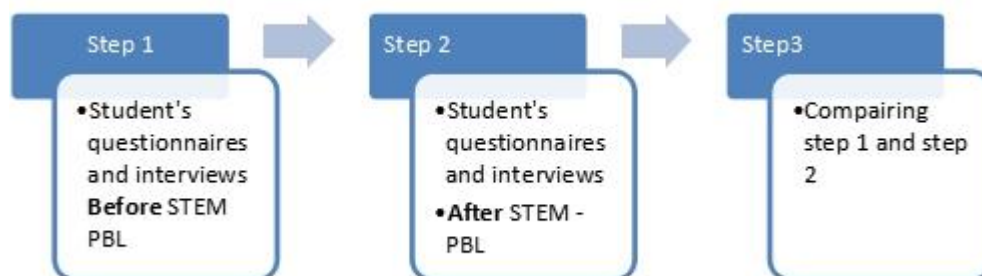


Figure 1: Three levels of the research PBL.

The design of the questionnaires was based on the effects of STEM-project based learning on 21st century skills and how the students improved after doing this kind of project. The 21st century skills such as: problem solving processes, collaboration, peer communication, contacting to real life

Creativity, design like engineers, and find solutions. The design of the questionnaire also based also on two types of questions which are the closed and open ended questions. The open ended questions were used to get all the possible answers to explore all feedbacks Capraro (2013) and check the student's knowledge.

Through-provoking questions also used in the questionnaires because it requires reasoning, logic, insight, and reflection Capraro (2013). The questionnaires made of three sections which are: the demographic information, check opinions and open ended questions.

The key concepts of this study are to find out the impacts of STEM project based learning on students learning and on their achievements. In addition to find out how the changing in gender and level will be effected by using STEM Project Based Learning.

This study includes three groups of participants. Group 1 involve the male students from grade 9 to grade 12. This group is in a private school in United Arab Emirates studying American curriculum. The group is made of 60 students. Group 2 is a female student from grades 9 to grade 12 in the same school. The female group contains 55 students. While

group 3 is made of the class teachers who participated and supervised this study. The teacher was science, math, and IT teachers. The administration participates also in this project somehow by informing the students with rules, remind the students with the time table, and announce for any new news. The administrator worked with teacher at the same time and at the same group.

Group of teachers and administrators aim to help the students in different ways to use STEM-project based learning subjects in their project. Teachers only from different subjects help for finding the results to find out how STEM-project based learning effect the students achievements by concentrating on the 21st century skills. Furthermore, the teachers interested to record any differences in results between the boys and girls.

Instruments

Data collected depending on two ways the qualitative and quantitative methods. As a result, a questionnaires and interviews used to collect the data from a higher grades student. 115 students were recruited in this study to collect the data and to analyze the result. Students were boys and girls and from grades 9 to grades 12. 115 questionnaires were printed out then distributed to the students, while the interviews had done with 40 students by choosing 5 from each class. The data from the interviews had recorded on the papers to get the results.

A quantitative and qualitative data are collected to the impacts of the STEM –Project based learning on the higher grades student's achievements. The data collected from grades 9 to grades 12 male and female students in a private school following the American system in the United Arab Emirates. Data collected by using questionnaires and interviews with the male and female students. 115 questionnaires and 115 interviews were collected in this study to record the data. Science, English, math, and IT teachers collected the data from the students.

The data which collected was to contrast and compare between STEM – Project based learning and a project without using STEM subjects. The data also was collected to persuade the students for the effectiveness of STEM subject in learning and to show them how it can facilitate the learning. Moreover, the data collected help the students to focus on the 21st century skills in the future. The collected Data from questionnaires and interviews have questions about real world problems, critical thinking, communication, group works, problem solving, using of technology and the leadership.

The following figure summarizing the three groups participate in this study

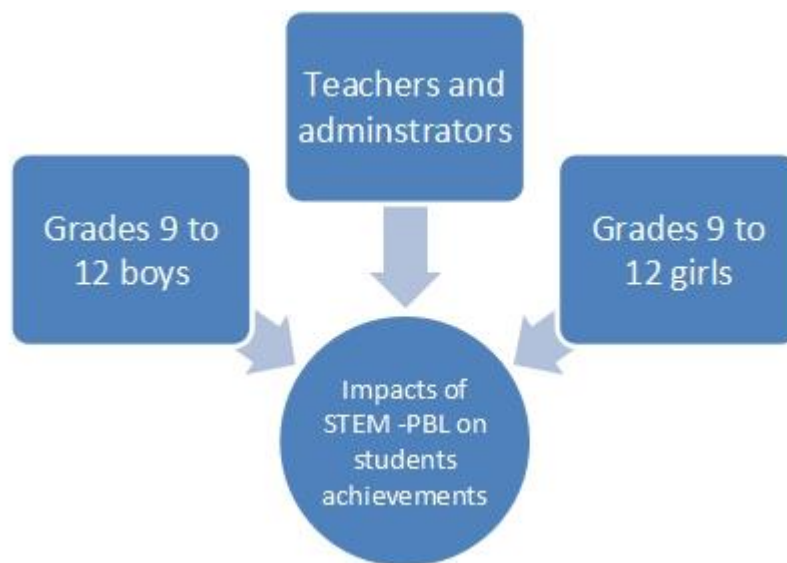


Figure 2: The population of the study

All the participants were aged between 14 to 17 in this study. Participants were recruited from one private school covering urban area.

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Describing the process

An ethical clearance was obtained from the school's administration prior to commencing the study. The clearance was a written paper from the science department to the administration. The ethical clearance had full details and instruction about the steps of the STEM- project based learning. The project had done in the private school that follows the American system. The school timing divided in to three terms, each term is made of about 3 months. The ethical clearance introduced in to administration in term 1 of the study, while the study started in the whole term 2 of the study. After obtaining the written informed consent from the administration, the study commenced by starting doing the plan for the whole term and distributing the tasks between teachers .

Two types of questionnaire prepared to get the students response and perception about the STEM-PBL. Two types of questionnaires were used, one was before the study and the second one was after doing the project. All of the participants were aged between 14 and 17 at the beginning of the study to investigate the impacts of the STEM-PBL on higher grades students and check their abilities for the university.

Project is planned to be divided into 2 groups on the basis of the degree of homogeneity of their sex into boys and girls. The percentage of boys to girl's participation was almost 1:1. Merely the boys increased than the girls by 5 participants. So the participants were from grade 9 one class from boys and one class from girls and the same thing happened with grade 10, 11, and 12 by choosing one class from boys and one from girls.

The project started by explaining the frame work of the project for the participants as follows: 1- Inform the participants about a competition starts to do a project by using 4 subjects (math, science, engineering, and technology). At that time the teachers remind the students about what is each subject about and what aims that each subject interested in. 2- Explain the competition: it is to do prototype for a rover who can move in mars planet to discover and gain knowledge about that planet. The rover must have people to move it and to discover more, the issue which didn't happen before. The participants also informed that they will use the STEM –subjects to achieve their project. 3- Participants can ask for help any time and they can ask teachers, google, books, or any source. 4- In addition, the students informed for the time limit of the competition which was for 10 weeks.

5- The also informed for the working area and the working time in the school every week. 5-The school administration chooses two hours in two days per week. Also the students have their choices to work at homes or at any free time during their school day.6- Participants also informed that there will be 2 winners for the best three rovers. 7- The projects also had marks which was a part of their project marks to encourage the participants to do their best.8- All classes, science laboratories, and the computer laboratories were prepared for the participants to do their works.

9-Teachers explained why also this project put it in a consideration which is interpreted for two reasons: the first one is to gain knowledge about the mars planet which in turn may help the society for something useful which will effect positively on everyone. The second is two improve their 21st century skills which will improve their future.

11-The participants informed to start by searching to collect data about mars planet to can find the problems and start to deal with them also to search for the previous triers to mars planets to get the pros and avoid the cons of that triers. 12- Participants informed for writing a report individually for each step and discussing their reports in groups to find out the final prototype then make a group presentation for their product.13-Interviews and evaluation decided to be every week to get a formative feedback.

Participants also informed the evaluation for the competition based on criteria as follow: A- The prototype should be based on the 4 subjects of the STEM-PBL, so the participant must show how science, engineering, math, and technology had been used in their rover. B- Bias must be avoided. C- The effectiveness of the design which overcomes the difficulties in mars planet. D- Reports and presentation.

A small sample was chosen because of the expected difficulties of their levels to measure their improvement and to evaluate their work to compare and contrast between their jobs with the other participants. Differentiation put in consideration in this study to measure the improvement of different abilities while doing the STEM-PBL. Another questionnaire had been used at the end of the project to get reflection to find the impacts of the STEM-PBL on the participant's achievements. The questionnaire also had closed questions and open ended questions. The questionnaire included also many questions about the 21st century skills to measure the improvement of the participants on their levels. At the end of the project participants started to compare and contrast between STEM-PBL and the old project which they used to do it without using the STEM subjects. The questionnaires were 115 before the project and another 115 after doing the project by using the STEM –PBL. While the written interviews with the participants had been used before the project, during the project, after the project, and if there is any clear development. Interviews played an important role for investigating the results after collecting data. The questionnaires also helped for collecting data to investigate the result, but their effects were less than the interviews which were more effective.

Many questions were used in the interviews. For example, to measure the use of math subject in the project a question asking about the geometry was used to ensure the use of math subject in this project. Also to measure the use of engineering in the STEM-PBL a question asking to help the participants to identify the problems they faced and how they deal with the problems. In order to identify the use of technology a students asked a questions in the interviews about which technology they used in their project.

Mixed method also used for a purpose of doing an accurate methodology by which the study can get good results. The method of this paper asked to stand on four purposes. The four purposes are: height measurement, accurate analysis, time limit, and defining the problem.

For the purpose of defining the problems, the methods for school's subjects were included in these studies which are math, science, English, and information technology. Each teacher from each subject informed to train the students how to solve the problems. Solving problems also had been taught during the normal lesson of the same school. The lesson plan of each subject must have a problem solving activity. Moreover, the study planned to guide the students how to solve the problems when they were doing their STEM-PBL. Teachers were responsible to guide the students to achieve the purpose of solving the problems. The questionnaire in this study also had many questions about the problem solving to help the students to compare between the two ways of doing projects and also to find out the effectiveness of STEM-Project base learning. For examples, one of the questions was: How many problems in your project? Another one was how do you deal with problems? Another question was how the STEM-PBL helps you to solve the problems.

Meetens (2003) affirmed also that several elements can be used in the process of mixed method to define the problem and searching the literature. He relates between the mixed method and solving the problems

For the purpose of height measurement, subjects were asked to stand on preparing all the classes, laboratories, library, and computer labs to facilitate the way of collecting data. Through the project the teachers also keep recording the observation and notes to obtain an accurate data and height measurements. Questionnaires and interviews are also prepared to get height measurements. The students informed to write reports for each step of working to measure their progress while doing their STEM-Project based learning.

Ethical Consideration

The current study pay the attention to the ethics depending on ethical principle of Hart (2005) which has been taken in consideration of human rights, probity, competences, and social liabilities. So before starting the study the permission had been taken from the school's administration. The purpose and objectives of the study also had been explained. In addition, all participants in this study such as the teachers, students, and administration were informed about the study, its purpose, and the methods. The questionnaires and interviews were used in this research, but the students were asked to participate or not before doing any step.

The confidentially and privacy had taken in consideration while doing the questionnaires. The next chapter is used to represent data analysis, finding, and the discussion.

Chapter 4: Results and data analysis

The current study aims to investigate the impacts of STEM (science, technology, engineering, and math) project based learning on the students achievements and checking the improvement of student's 21st century skills. This chapter present and describe the results in a systematic and detailed way. The results of the current study rose after gathering a qualitative and a quantitative data.

The data have been collected after informing the higher grades student (male and female) in the United Arab Emirates to make a project to produce a rover by using STEM subjects. The rover should be useful to discover the Mars planet and must be designed to involve people inside it. The data collected from pre and post questionnaires and from many interviews with the students. First, the questionnaires were distributed to the students, and then followed by many interviews with the students to get more accurate results.

The current study focuses on 4 categories which are: **1)** Investigating the effect of STEM project based learning to improve the student's engineering skills.

2) Investigate the effect of STEM-PBL on the development of student's 21st century skills. **3)** Find out the relation between STEM-PBL and the real life. **4)** The advantages of subject's integration in STEM.

Total of 130 surveys (quantitative data) to investigate the impacts of Stem Project Based Learning by producing a rover prototype on the achievements were distributed among students in a high school (American curriculum) in Al Ain city, 15 surveys were returned giving a response rate of 88.5%.

This chapter starts by the demographic information, then the results produced from the relation between STEM-PBL and engineering, after that to represent the results that investigate the effect of STEM-PBL on the development of 21st century skills, then to find the effect of STEM-PBL on their real life, then reporting the student's toward the STEM integration, after that representing the overview on the legionnaire's results, and finally to analyze the student's interviews.

Demographic Information

The table below provides the overview of the students participated in this study based on their gender, grade level, and nationality. From the data in the table 1.1, it is apparent that there is a significant variety between the students ages which wider the range of this study.

Table 1.1: Distribution of Sample According to Demographic characteristics

Characteristics	Category	N (%)
Gender	Male	60 (52.2)
	Female	55 (47.8)
Grade Level	Grade 9	15 (13.0)
	Grade 10	30 (26.1)
	Grade 11	35 (30.4)
	Grade 12	35 (30.4)
Nationality	Local	25(21.7)
	Non-local	90(78.3)

Table: Percentage of students' demographic information.

The demographic characteristics showing that (n= 60, 52.2% male and n=55, 47.8% female) Table 1.1. Moreover, the result shows that 78.3% (n=90) of the students are non-local, and 21.7% (n=25) of the students are local. The pie chart below shows the distribution of the students who participated in the current study according to their genders. What is interesting in this data, those percentages of the number of male students and female students that they are close to each other? Overall, STEM-PBL didn't affect males and females differently in these measures.

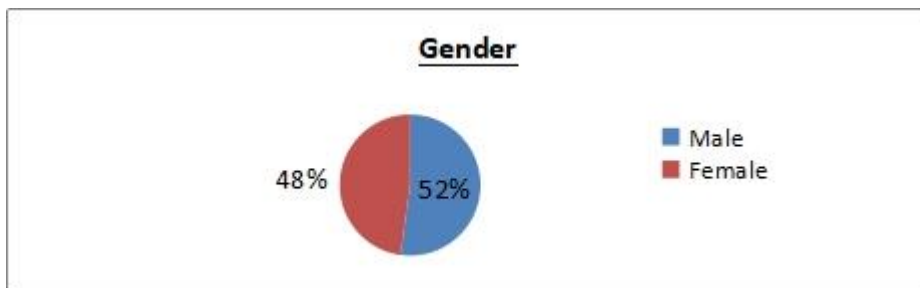


Figure 1.1 Distribution of respondents according to Gender

From the graph below we can see the distribution of the students according to the grade level. Starting by 13.0% (n=15) of the students of grade (9), 26.1% (n= 30) of the students of grade 10, 30.4% (n= 35) of the students of grade 11, and 30.4% (n= 35) of grade 12. Strong evidence of the positive perception of the students for the impacts of STEM-PBL on their learning found when the grade 12 students revealed the highest agreement according to their ages.

The figure below shows distribution of students according to grade level.

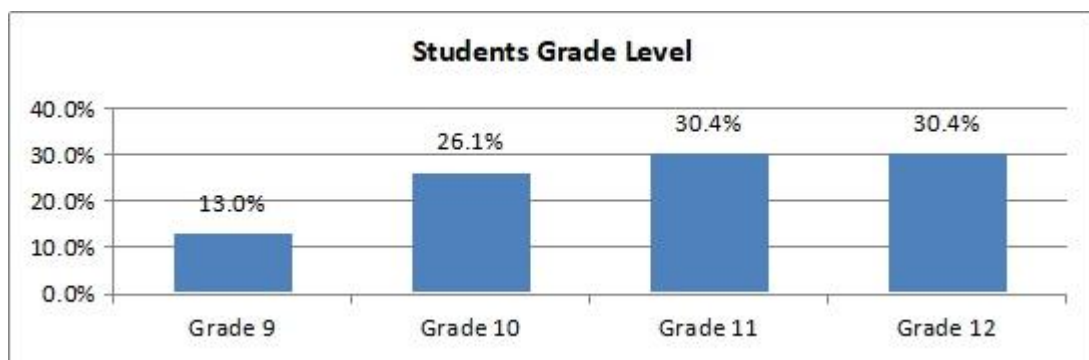


Figure 2.1 Distribution of students according to grade level.

STEM-PBL and engineering

The first category in the questionnaire aims to measure the impacts of STEM-PBL on improving the student's engineering skills after doing the project. This part of questionnaire includes some questions to identify if the STEM-PBL: 1) Foster the problem solving processes.2) Challenges and motivates the students to find better solutions.3) Fostering the observation and help for making analysis.4) improvement the designing skills.5) designing better solutions. 6) Find solutions. The result of the questionnaires revealed a strongly agreements with a mean appeared in this statics is (1.0).

While the distribution of sample according to satisfaction with STEM-PBL revealed that 111 higher grades students (96.5%) agreed that STEM-PBL enhanced all their engineering skills. In addition, only 4 higher grades students disagree (3.5%).

STEM-PBL and 21st century skills

The second category in the questionnaire aims to investigate the improvement of 21st century skills after implementing the STEM-Project based learning. This part in questionnaire includes questions to identify if the STEM-PBL: 1) encourages collaboration. 2) Encourages the peer communication. 3) Enhance the higher order thinking skills. 4) Improves the critical thinking skills. 5) Enhance the creativity. The results of this part was strongly agree and a mean value (0.95). On the other hand, the distribution of sample according to satisfaction with STEM-PBL revealed that 112 of higher grades students (97.4%) agreed that the skills of 21st century skills improved after doing the project by using STEM subjects. While 3 students of a higher grade students (2.6%) disagreed.

STEM –PBL and the real life

In response to the question that indicates that STEM-PBL changes the way of thinking, most of the answers (95.7%) agreed that STEM-PBL play a great role on that change. The majority of those who responded to the relation between STEM-PBL and the real life confirmed that the project fostering them to be a good researcher. Majority of the participants in this study indicated that this kind of projects help them to know how to define, manage, and assess their works.

The results of this part of the questionnaire revealed that the students strongly agreed that the STEM-Project based learning enhance their real

life after this kind of integration between the subjects. The Distribution of sample according to STEM-PBL revealed that the mean value for the effect of STEM-PBL on the real life progress is (0.88). The student's response rate that confirms the positive relation between the STEM-projects based learning and the real life which affects positively their future careers was (95.7%). So, 110 students agreed while in the other hand, 5 students with a percentage (4.3%) disagreed and didn't reveal satisfactions with the use of STEM-project based learning. This section of questionnaire revealed that 110 of the students had a positive attitude and perception that STEM-PBL can prepare them for the future careers. Consequently, they also approved that STEM-PBL has a great contact to the real life skills.

Responses of STEM integration

The category of STEM integration in the questionnaire revealed the greatest response throughout the whole categories. Total of 113 students with a percent of (98.3%) respond with a strongly agree and the mean of the effect of the integration of STEM was (1.0). However, 2 students with a percentage (1.7%) dis agreed with the effect of STEM integration. The overall responses to the questions were very positive. Data from the questionnaire revealed that 98.3% of the students affirm that STEM-PBL :1)doesn't depend on memorization 2) enhance the project performance 3)makes the project attractive and clear because of these integration between the subjects 4) reduces the requirements of unskilled worker5) organization increased after using STEM-PBL 6)is a Meaningful multidisciplinary approach.

Overview on results

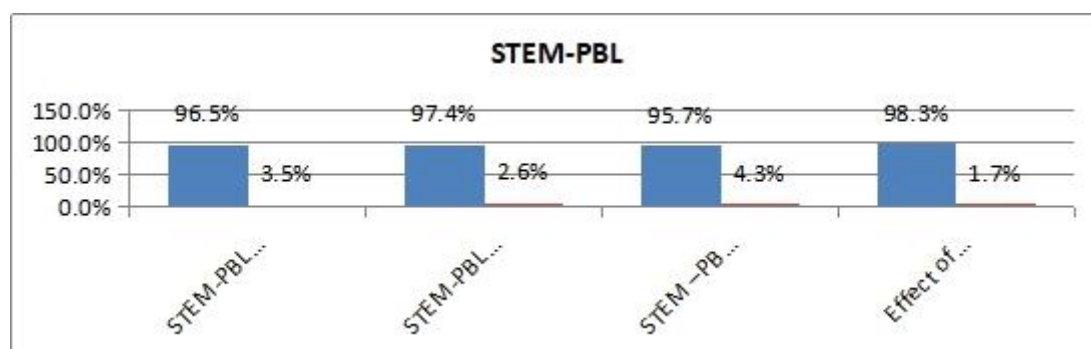
The results obtained from the questionnaires analysis are summarized below in the following tables and graph.

Table 2.1: Distribution of sample according to STEM-PBL

Parameters	Mean	Result
STEM-PBL and engineering	1.0	Strongly Agree
STEM-PBL and 21st century skills	0.95	Strongly Agree
STEM –PBL and life	0.88	Strongly Agree
Effect of integration of stem	1.0	Strongly Agree

Table 3.1: Distribution of sample according to satisfaction with STEM-PBL

Parameters	Agree	Disagree
STEM-PBL and engineering	111(96.5%)	4(3.5%)
STEM-PBL and 21st century skills	112(97.4%)	3(2.6%)
STEM –PBL and life	110(95.7%)	5(4.3%)
Effect of integration of stem	113(98.3%)	2(1.7%)



The overall response to the questions in the questionnaires was rich. The most effective category appears from the results is the perception of students for the effectiveness of STEM integration on their learning and on the developing of their skills for the future careers. Interestingly, there were differences in the ratios of STEM integration and STEM with real life. This difference indicates that the students have less understanding for the relation and the effectiveness of STEM on the real life because the percentage was less (95.7%). On the other hand, there was a close positive result for the perception of the importance of STEM for the improving of the 21st century skills and for the perception for the importance of the STEM integration. The single most striking observation to emerge is the role of engineering in the STEM subjects which indicates the importance of learning the students for the strategy of solving problems.

There is a dependent variable between STEM-PBL and the four groups (engineering, 21st century skills, life, and the integration between subjects). The purpose was to investigate significant differences between each group and the student's characteristics (gender, nationality, and the grade level). The results revealed that the STEM-PBL and life with the grade level was 0.011 while in case of nationality it was 0.001 which indicates that there is a significant difference between STEM-PBL and the student's characteristics. The P-value confirms these differences which was less than (0.05). The following tables show the significant value for each character.

Chi- Square test (P- Value)				
S/No.	Perception items	Gender	Grade Level	Nationality
1	STEM-PBL and engineering	0.000	0.000	0.000
2	STEM-PBL and 21st century skills	0.000	0.000	0.000
3	STEM –PBL and life	0.000	0.011	0.001
4	Effect of integration of stem	0.000	0.000	0.000

Table 4.1, Shows that there is a significance difference between STEM-PBL and students characteristics ($p < 0.05$).

S/No.	Perception items	T-Test	P-value	Result
1	STEM-PBL and engineering	-1.22	0.004	S*
2	STEM-PBL and 21st century skills	0.57	0.003	S
3	STEM –PBL and life	2.51	0.012	S
4	Effect of integration of stem	-3.21	0.021	S

* Significant at 0.05 level

Table 6.1 ANOVA analysis between STEM-PBL and grade level

S/No.	Perception items	F-Test	P-value	Result
1	STEM-PBL and engineering	0.142	0.081	NS*
2	STEM-PBL and 21st century skills	0.324	0.142	NS
3	STEM –PBL and life	0.452	0.042	NS
4	Effect of integration of stem	1.021	0.071	NS

* Not Significant at 0.05 level

Student's interviews analysis:

Total of 60 interviews (qualitative data) had done with different grade level students to ensure the impacts of STEM-PBL on students learning by making a rover prototype to confirm the results got it from the questionnaires. The interviews were with a high grades students (American curriculum) in Al Ain city in the UAE. The interview's questions were to investigate the role of STEM project based learning on enhancing the students learning by checking its effects on developing the 21st century skills, on developing the engineering skills to help the students strategy of solving problems, and to affirm the relation between STEM-PBL with the real life. 100% of those who were interviewed indicated that they liked this kind of project and they expressed that they improved in their learning.

Interviews about the enhancement of 21st century skills

At the beginning the questions of the interviews were prepared and grouped in to 4 main areas: 1) communication and team work 2) problem solving 3) critical thinking 4) creativity and imagination.

When the participants were asked if the STEM-PBL improves their 21st century skills, the majority commented that they completely improved and they added that they gain some skills that they had never been know it. One individual stated that “ I am ready for the next project because I liked to create new things "And another commented “ STEM is suitable for me because I like understanding rather than memorizing”.

The common view among the interviews was that there way of thinking is completely changed. All the respondents indicated that this is the first time collaborate and work in the team work. 70% of the participants in

the interviews confirmed that they liked STEM-PBL because of the creativity and the imagination, while some of them commented that they liked critical thinking which is the most part of all skills. In addition, when the students were asked about solving problems, 80% commented that they liked the project because they solved many problems especially that one which is related to their real life.

A group of question about the 21st century skills was categorized to investigate how skills affect the abilities. These results are listed below.

Skills and abilities	Interviews results
enthusiasm for learning	95%
deep understanding application of learning	96%
examination, inquiry, critical thinking and reasoning	99%
communication – write well, listen effectively, discuss intelligently, be proficient in a foreign language,	95%
cultural, social, and environmental - understanding and implications	99%
technology – understand the computer as an information, computation, and communication device, and the world of computers, electronics, and related technologies	98%
diverse learning across a broad range - fine arts, performing arts, and vocational	94%

Interviews STEM-PBL and engineering

Some questions had been used in the interviews with the students to investigate if STEM-PBL improves the student's engineering skills by which the skill of how to solve problems is also improved. STEM (science, technology, engineering, and math) involves only one subject in STEM subjects which is considered as a new subject. The new subject is engineering which is put in consideration to explain it and support the students to understand it. Four abroad results emerged from the analysis of the interviews to explore their perception and attitudes for the effect of engineering on their work. First, when the students asked about the problems they faced 92.8% of the participants commented that they faced some difficulties at the beginning when they treat with the problems but after facing many problems they affirmed that the strategy of solving problems becomes easier. On the other hand, 7.8 % of the students answered that they already like the treatment with the problems.

Second result in this part appears when the students asked about the strategy of solving problems. Of 60 participants who responded to the interviews, 20% of the students reported that they create a strategy to solve the problems. While 95% of the participants ensure that working in groups help them to solve most of the problem they faced. The answers of the interviews revealed that 20% of the participants solved about 95% of the problems, while 70% of the participants solved about 80% of the problems. In addition, 10% of the participants commented that they solve some of the problems about 40%.

In the final part of the interviews, students were asked to conclude the relation between STEM-PBL and the 21st century skills.

Questions in the interviews indicates that some interviewees argued that after using STEM project based learning their communication improved which leads to enhance the job and get better solutions, while others 20% affirm that they started to think critically after dealing with STE-PBL. 5 students out of 60 stated that they were responsible for creating new ideas and products in their groups. The minority of the students mentioned that the STEM-PBL takes long time at the same time all students agreed that STEM-PBL enhances and effect positively on their 21st century skills which will help them for their future careers.

Comparing the two results from the questionnaires and the interviews, it can be seen that the students had a positive attitudes and perceptions toward the STEM-Project based learning. The comparison between the two results confirms the very close relation between the STEM-PBL and the 21st century skills.

Overall, these results indicate the positive effect of STEM-PBL on the 21st century skills which in turn reveals its positive effects on the student's learning. In summary, these results show the effectiveness of STEM-Project based learning on the improvement of the student's learning.

Discussion, conclusion, and implication

The integration between the subjects (Science, Math, Engineering, and Technology) revealed enormous changes for the student's level in this study. Student's abilities showed an improvement through the STEM-project based learning. The idea of integration between subjects contributed in enhancing the student learning because the integration helped them to get more information which leads to better and clear understanding for the idea. The effect of STEM-PBL appears great and significant in this study because this is the first year (2018) at which the student tried to integrate between subjects. One of the most important outcomes in this study that the students assessed themselves and STEM-PBL also helped the teachers to assess their students and evaluate their works.

Discussion, recommendation, suggestions, conclusion, and the current study's limitation are presented in this chapter.

Discussion

The current study is conducted in the United Arab Emirates in Al Ain city in a private school. It involved the high grades students from grades 9 – 12. The purpose of the study is to investigate the impacts of STEM (science, technology, engineering, and math) project based learning on the students learning by exploring their achievements and the developing of their 21st century skills. The study aims also to encourage the students to study by this kind of integration between the subjects. The study started in the second term of studying and extends to the third term, so it extended for about 4 and half months.

The students asked to produce a rover prototype by using STEM-PBL. 130 students participated in this study. The study focusing on 4 categories which are : effects of STEM-PBL on the student's 21st century skills, the effects of STEM-PBL on development of student's engineering skills, advantages of STEM integration, and the relation between STEM-PBLE and the real life. In addition, the current study aimed to find out if there are any differences in results between females and males students. A strong relationship between STEM-PBL and the 21st century skills has been mentioned in the literature review of this research to emphasize the role of STEM-PBL in helping the students to gain this kind of skills. A mixed research method is used in this study to get a quantitative and qualitative data. The study also referred to many previous studies.

STEM-PBL could reveal a positive or a negative feedback. But as mentioned in the literature review and as appeared in the results, the STEM-PBL revealed a significant effect on the student's achievement and some of the negative feedback when the students mentioned that it needs long time to achieve the project. Many prior studies have noted the importance of STEM-project based learning on the development of the student's achievement by developing their higher order thinking skills (Ejiwale, 2012). Facilitating Teaching and Learning across STEM Fields. not a sentence claimed that all the higher order skills (collaborative, design, creativity, problem solving, product solving, and the critical thinking) can be developed by STEM program. A strong relationship between Stem-PBL and the 21st century skills has been reported in this literature to emerge the effectiveness and importance of STEM-PBL.

Student's feedback

The current study found that the student 21st century skills have been improved and affected when the STEM-project-based learning is implemented. The results revealed also a great change in the student's level when their skills had been improved. The change appears when the students start just the current year (2018) to integrate between subjects. This great change got it from the observations, questionnaires, and the interviews. One of the most interesting was when the students used to solve the problems which were the first time to deal with problems effectively. In this study a great communication was found to cause a big change in the student's results during doing their projects. The students point at the communication several times in their interviews and also in their questionnaires.

STEM-PBL was also a great indication for the student's understandings because all the feedback which got it shows the improvement on the student's level when it compared to the last previous projects. The results of the current study indicate that the students solved several different problems when they apply the STEM-PBL. Also the same idea was concluded by Capraro and Sun Yung Han (2014) when the study emphasized that STEM-PBL influenced the student's achievements especially in math skills. In addition, the current study interviews revealed the students used to ask themselves many different questions which forced them to search, communicate, and cooperate to find the solution.

The most important problem was when the students help each other to create a rover under three main criteria: the first one was to make it suitable with the mars planet conditions, the second one that the rover should be cheaper, while the third one was to avoid the repetitions. One of the interesting note in the current study that in almost all of the students liked to do their project by using the STEM-PBL subjects and they are looking for repeating this for the next time.

On the other hand, few of them didn't get the idea and they face some problems because of their weaknesses in using the English language. Furthermore, the result of this paper didn't show that STEM-PBL wastes the time because the students produced good rovers and few of them were awesome. So, the STEM-PBLE would have been useful.

Effects of STEM-PBL on the developing of 21st century skills

The results of the current study found that STEM –project based learning shows significant effects on the development of the student's 21st century skills. In addition many other studies support the same idea. For example, A study of Nelson (2011) compare between STEM and non-STEM learning when he conclude that the student who graduated from a STEM school reveals more ability and become more achiever than that one who graduated from school which doesn't use the STEM subjects.

A dissertation submitted by Hui Hui Wang(2012)to the graduate school of Minnesota university to affirm also the effectiveness of STEM on the development of 21st century skills for the students focusing on the problem solving skills. In this dissertation the teacher's perceptions analyzed and discussed to find out that all teachers emphasized the importance of independent thinking for the real life and develop the

quality of the future careers. Similarly, one of the most important results in the current study is the positive attitude and perception of the students towards the improvement and establishing of the 21st century skills. One of the strength areas in the current study is to analyze the student's perceptions after doing the project using STEM to ensure the progress of these skills focusing also on the problem solving strategy.

In addition, Han (2015) pointed out the importance of correlating between the group works and the STEM –PBL to help the students cooperate to attain all the 21st century skills. Likewise, the same result appeared in the current research when the students did their project in groups. In the current research the students understood how to work as a group which leads to achieve their targets. There is no contradiction found between Han's (2015) and the current paper. Both research studies followed quantitative and qualitative methods to find the positive impacts of STEM-PBL on the students' achievements concentrating on the 21st century skills. Both studies also conclude that STEM-PBL enhance the student's learning. Hui Hui Wang (2012), Han (2015), and the current research believe the necessity of implementing the STEM-PBL by grouping the students which revealed positive results toward the progressing of 21st century skills for the students.

Effects of STEM-PBL on the Student's achievements

The second question in this study sought to investigate how much STEM-PBL improves the student achievement. It was hypothesized that about 60% of the students will improve, but the results indicate that 98% of the students revealed an a great improvement in their learning by developing their achievements and by getting more skills related to 21st century skills. A rubric had been used in this research to investigate the impacts of STEM-PBL on the student's achievements. Two questions had been used in the rubric to find the results. The questions were to ask if the STEM-PBL effects the student's achievement or doesn't effect. The results indicate that student's level improved which appears in their achievements and their results. The results of the current study affirm that STEM –PBL improves the engagement, cooperation, attention, awareness, knowledge, skills, and passion which in turn improve their achievement and their performance. But the most important and observed result was the participation of all student effectively which makes them to have a passion for producing and creating a new and different project. What is surprising is that all students participate in this study improved and their achievement developed compared with previous projects at which they didn't use the STEM project based learning. The finding of the current study is consistent with those of Bradly-Levine, Mosier& Perkins (2013) which confirm also that STEM-PBL helps students to be involved in learning, increase their passion which lead at the end to improve their achievement in doing the project or generally in learning.

There are some factors may explain the relatively good correlation between STEM-PBL and the students achievements: the most important factor is when the students start to integrate between the subjects they obtain more knowledge and gain more skills and knowledge which help in improving their achievements and their learning.

Another factor is that STEM support and enhances the 21st century skills which in turn lead to enhance the student's achievements and prepare them for the future career. The combination between STEM-PBL and student's achievements provide some support for the usefulness of implementing STEM-PBL in learning.

Student's perceptions toward STEM-PBL

The current research set out with the aim of exploring the importance of implementing STEM project based learning for a higher school student in the United Arab Emirates. It is also aims to find out the student's perception toward this strategy. The students informed to do a project, but the initial objective for the project is to identify their perception because they are the basis of learning.

The questionnaires in the results of this study indicates that the students became able to find a solutions for many problems, work in a team work and independently, compare, relate, create, analyze, evaluate, explain, describe, and critically thinking. Furthermore they relate their knowledge with the real world, apply in their real life, and prepare themselves for the future careers.

In addition, the interviews revealed also their positive attitude towards this new strategy. The results shows also that all the students preferred the STEM specially when they informed to compare between doing the project by using STEM-PBL and the old way which they used to do their projects. One unanticipated finding from the interviews that students ask a lot about the next project to use the same strategy and some of them shred with some new ideas such as sharing their projects with other schools rather than to be indoor only which amazing idea. The finding of the positive attitude toward STEM-PBL is in agreement with many previous studies such as(Russel et al., 2007; Toker& acker man, 2011; Wyss et al 2012). The students mentioned that they started to decide for their future careers after they treat with engineering, and technology. Some of them also had chosen their career for the future after finishing their project. So Stem-PBL opens the students mind, enhance their thinking, and help them to gain knowledge. STEM-PBL also supports the students to hypothesize in each problem which appear through the problems they faced.

Implications

Students in the current study gain the 21st century skills that are necessary for science, math, and engineering. They used to solve problems, thinking critically, synthesize a prototype which must be suitable for Mars conditions, so they analyze to create, and they always used to get a feedback to evaluate their works. Technology also had been used continuously to connect their works with the real world. Collaboration was always done by the students and independent work when it is needed.

The explicit design in STEM project was the integration between science, math, engineering, and technology to produce a rover suitable to discover

the Mars planet. Students faced difficulties in two things: the first one was to solve mathematical problems and they spent long time to relate their work to the real life which was acceptable because this is the first time they make their project by using STEM subjects? On the other hand, they were interesting with science, technology, and engineering. The management of time and for the project was one of the most important implications in this research. Motivation, self –development, and following the students work up were always the role of teachers whose participated in this research. Because of participants of this research was the first time working with STEM subjects, so more work will be necessary to determine to what extent the constructivism in the different disciplines of STEM is achieved. Further studies could be also conducted to measure the critical thinking which consider as one of the cognitive study.

Conclusion

This study sits out to investigate the impact of science, technology, engineering, and mathematics project based learning (STEM-PBL) on the achievements of high school students in United Arab Emirates. This study was undertaken to design prototype of rover can be used in Mars planet. The rover had two conditions: The first is to be with people inside it, while the second condition is to overcome all difficulties present in the Mars planet. This study has found that generally STEM-PBL has positive impacts on the student's achievements and learning. The most obvious findings are 1) the progress of the 21st century skills which lead to good learning.2) the students liked STEM and preferred it than what they used to do before.

The results of this study indicate that the use of STEM-PBL plays an important role for student's learning and it has a positive perception by the students in both genders.

So the current study provides additional evidence for the effectiveness of STEM-PBL in learning with respect to the grade level.

Limitation

The generalizability of this study is subject to certain limitations. For instance, it would be better if the study takes longer time than 2 months. In addition the, it seems to be more accurate if the study occurred for a wide range of students levels and grades rather than to be for higher grades only. Not enough resources considered as another limitation in this study. So, the use of robotics and other resources may improve the results and increases the student's engagement. Also if the study contains more teachers rather than 5 teachers only will help for displaying more ideas.

Recommendation

It is recommended that further research be undertaken in the following areas: 1) Increasing the range of participants.2) All teachers should have good information about STEM and recent researches.3) It would be better if administration participate also in the study.4) Further research should also concentrate on the investigation of the parents' feedback. 5) One of the good thing happened in this study that it had done during the studying hours for two hours per week, while it is recommended to be more than two hours. 6) It seems to be more accurate if the study covers more than one school to compare, analyze, and discover other limitations.

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Appendices

Student's survey

Student consent form

Dear students, I am doing a research to investigate the impacts of using STEM-PBL(Science, technology, engineering, and mathematics project based learning) on learning by investigating its effects on the improvement of 21st century skills. If you would like to participate in this study I will ask you some questions related to this idea. If you will change your mind for the participation, inform me by email or even calling. During and after the study I will write about any new knowledge or information gained from this study, but with a secret personal information.

If you want to participate in my study, please write your name down in this paper. Copies will be kept with me, you, and your parents.

Researcher,

Hani

Voluntary agreement form:

I have read the information in this study and I understood all steps, so I agree to participate in this research. I have the right of withdraw any time. I have received a copy of this form.

Student full name _____

Signature _____

Date _____

I certify that I have explained to the student the purpose, steps, and nature of the study. Also any question have been raised is answered.

STEM-PBL challenges and motivates me to find better solution					
STEM-PBL encourages collaboration					
STEM-PBL encourages the peer communication					
STEM leads to higher – order thinking skills -PBL					
STEM-PBL improves critical thinking skills					
STEM-PBL is contacting to real life					
STEM-PBL changes the way of thinking					
STEM-PBL leads to creativity					
Using STEM-PBL helps me to be a researcher					
STEM-PBL doesn't depend on memorization					
Integration between subjects serves me to do better project following the STEM PBL					
Integration make the project attractive and clear					
Machines availability in STEM-PBL reduces the requirement of unskilled worker					
STEM-PBL makes the project well organized					
I used observations and analysis more than before implementing the STEM PBL					

STEM-PBL helps me to design like engineers					
By using STEM-PBL I be able to define, manage, assess project efficiently and successfully					
STEM-PBL equips me with the 21 st century skills					
STEM-PBL helps me to design better solution					
STEM-PBL aims to find solutions					

Overall I am satisfied with using STEM in education

Definitely agree	Mostly agree	Mostly disagree	Definitely disagree

Personal development

STEM helped me to develop transferable skills such as communication, group works, IT usage,...

Definitely agree	Mostly agree	Mostly disagree	Definitely disagree

Section C: Open ended questions

Please answer the following questions to your best.

1- What is STEM-PBL?

2- How STEM-PBL improves your skills?

Student Interest Survey: Technology

Instructions: The following statements relate to beliefs and interest in technology.

Mark the column that most closely matches how you feel about each statement.

1 = the least agree

5 = the most agree

Beliefs about Technology	1	2	3	4	5
I enjoy technology class					
I get to do experiments in my technology class					
I want to take more technology classes					
I like to find answers to questions by doing Experiments					
Being a technologist would be exciting <hr/>					
The technology is difficult for me					
I like to use the technology book to learn technology <hr/>					
I like to use computers to learn about technology					
Technologists help to make a better life					

Student Interest Survey: Engineering

Instructions: The following statements relate to beliefs and interests in engineering.

Mark the column that most closely matches how you feel about each statement.

1 = the least agree

5= the most agree



Beliefs about Engineering	1	2	3	4	5
I enjoy engineering class					
I like to find answers to questions by doing experiments					
I like to use the engineering book to learn engineering					
Engineers help make our lives better					
Engineering is difficult for me					
I like to work in a small group in engineering classes					
Engineering is useful in everyday life					

Being an engineer would be a lonely job					
I want to take more engineering classes					
I like to use computers to learn about engineering					

Questions of interviews

- 1- What difficulties have you faced while doing the project?
- 2- How do you evaluate the project? Like/dislike
- 3- What are the main skills you gained from this kind of project?
- 4- Do you like to work with this experience again?
- 5- Did you explore something new?
- 6- Did you create or try to create something new?
- 7- Do you have a passion to do like engineers?
- 8- Do you like to use technology in different way?
- 9- Does your understanding about technology changed?
- 10- Do you get more knowledge?
- 11- Does the way of thinking is changed after doing the project?
- 12- Which is better, the integration between subjects or not?
- 13- What is your opinion about this project?

Collaboration Skills

In general, collaboration skills refer to students being able to work together to solve problems or answer questions, to work effectively and respectfully in teams to accomplish a common goal and to assume shared responsibility for completing a task.

1. The following questions are to measure the student's achievements in a communication skill:

Dear students, Do you like:

- 1- To Work in pairs or small groups to complete a task together?

- 2- To Work with other students to set goals and create a plan for the team?

- 3- Create joint products using contributions from other students?

- 4- To present your work to others?

- 5- Work as a team to incorporate feedback on group tasks or products?

- 6- To give feedback to peers or assess other students' work?
