Investigation of implementing STEM projects in a selective school in the United Arab Emirates

التحري عن تنفيذ مشروع (ستيم) في مدرسة انتقائية في الامارات العربية المتحدة

by

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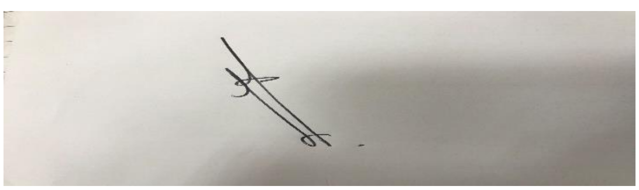

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Abstract

STEM education is trending nowadays due to the high demand for STEM careers. A range of countries are developing their educational systems to be capable of producing the required highly qualified future degree holders. It is critical that educational systems adapt to this change. The UAE is one such country with a high demand for engineers, scientists, mathematicians and technicians. Consequently, the focus of key decision-makers and stakeholders is to put the latest educational theories into practice.

As a result, this study aims to investigate the implementation of STEM projects in one selective school. The study will focus on six main factors: group formation, differentiation, achievement, motivation, assessment and to identify any gender differences. To ensure the effectiveness of the study, a mixed method was used, including questionnaires being issued to both students and teachers. After analyzing the quantitative data, some interviews with teachers and students were conducted to provide further insights and to address any gaps in the data. The results show that STEM initiatives have a positive effect on the motivation and achievement of students. Students are satisfied with the assessment and group-building procedure. STEM projects are pedagogies that suit students with different abilities. The results show a significant difference in attitudes between males and females toward STEM projects and STEM careers.

Key words: STEM PBL, STEM projects, motivation, achievement, differentiation, assessment, group formation and gender differences.

الملخص

يتكلم العديد من التربويين في هذه الايام عن مشاريع العلوم والتكنولوجيا والهندسة والرياضيات (ستيم) و ذلك بسبب ارتفاع الطلب على وظائف و مهن (ستيم). وتقوم البلدان المحتاجة لهذه الخبرات بتطوير نظمها التعليمية لتكون قادرة على إنتاج خريجين مؤهلين بما يناسب حجم سوق العمل. وهكذا، يجب أن تتكيف النظم التعليمية مع التغيير. ولذلك، فإنها تتجه لضبط نظمها التعليمية وفقا لذلك. ومع ذلك، فإن الإمارات العربية المتحدة هي واحدة من هذه البلدان التي تحتوي ارتفاع الطلب على المهندسين والعلماء وعلماء الرياضيات والفنيين. لذلك، يركز أصحاب القرار في تقديم أحدث النظريات التعليمية في الممارسة العملية.

ونتيجة لما سبق، تهدف هذه الدراسة إلى التحقيق في تنفيذ مشاريع (ستيم) في مدرسة انتقائية واحدة. حيث يتم التركيز على ستة عوامل رئيسية هي: تشكيل المجموعات، الفروق الفردية، الإنجاز، التحفيز، التقييم والتحقق من أي اختلافات بين الجنسين. و للتأكد من فاعلية الدراسة، تم استخدام طريقة البحث مختلطة. واستخدمت استبيانات لكل من الطلاب والمعلمين. وبعد تحليل البيانات الكمية، أجريت بعض المقابلات مع المعلمين والطلبة لتغطية الفجوات. وأظهرت النتائج تأثير إيجابي من (ستيم) على الدافعية والإنجاز. كما وجد ان الطلاب راضون عن التقييم وإجراءات بناء المجموعات. كما تم ايجاد ان لمشاريع (ستيم) اثر ايجابي على مراعاة الفروق الفردية بين الطلاب. كما أظهرت النتائج وجود فرق ملحوظ بين الذكور والإناث نحو مشاريع (ستيم)

الكلمات و العبارات الرئيسية: ستيم، الدافعية، الإنجاز، الفروق الفردية، والتقييم، وتشكيل مجموعة والاختلافات بين الجنسين.

Dedication

Completing this dissertation was one of the most difficult experiences in my life. The encouragement of my professor, and the support of my family and friends made it possible. I dedicate my dissertation to my family and friends. My mother's and my wife's words of encouragement and their push for tenacity, in particular, still ring in my ears.

I harbor a special feeling of gratitude to my wife Suheir, who supported me and inspired me throughout this journey. Suheir has always encouraged me to believe that I can achieve any objective I set myself with determination and hard work. I also dedicate this piece of work to give special thanks to my mother for her constant concern and phone calls to follow-up with me. I would also like to thank my brother Ayman who consistently influences my commitment to work. I also wish to dedicate this dissertation to my lovely kids for sacrificing the time which I should have spent with them, their smiles and laughs were always the key to maintaining my motivation. I also dedicate this work to my best friends and colleagues who supported me with their words during the years of my study.

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Chapter 1: Introduction

We live in a connected global community. Issues involving Science, Technology, Engineering and Mathematics (STEM) are commonplace in the media. The world around us changes rapidly, as result education should reflect these changes accordingly (Rennie, Venville and Wallace 2012). Thus, one of the most important targets of STEM is linking secondary education with post-secondary practices. Job success depends on the interaction of knowledge from within each, and also across STEM disciplines (Capraro, Capraro and Morgan 2013).

STEM is an important affirmation all around the world, trying to empower the educational outcomes by well-qualified graduates (Riegle, Grodsky, and Muller 2012; cited in McDonald. 2016). By encouraging students to study STEM subjects and selecting STEM majors as their careers in the future, countries maintain the minimum levels of engineers, educators and technicians they require to handle the increasing need in manpower (Wan Husin et al. 2016).

1.1 Science, Technology, Engineering and Mathematics STEM

Lewis, Capraro and Capraro (2013) argued that in the previous ten years, STEM education became more known by educators, and appears more frequently in the National Science Foundation (NSF) agenda in their yearly meetings. A need of generation empowered by STEM subjects face the global economic crises and challenges. The aim of STEM is to provide the market with the required professionals in the fields of STEM. To help teachers implementing STEM projects effectively in schools, help prepare them in joining professional development sessions in aiding teachers to plan well-designed activities to engage students in integrated STEM project based learning activities, which are very important. The outcome will be a generation provided with, skills such as critical thinking, problem- solving, analysis and communication skills.

In order to build a generation who can compete in the economical changing universe, and maintain the nations strong demand between other nations, without the need of manpower of other countries, we need to prepare a generation who can take future responsibilities We need a generation who is creative and able to solve problems, as well as change old teaching lecturing methodologies into STEM project based learning (Wan Husin et al. 2016). There is a need to encourage more graduate students toward STEM fields to compete other industrial countries. Applying STEM effectively would produce high quality engineers and teachers who can compete in the international congestion and can fit in the national and international vacancies and needs (Hathcock et al 2015).

Rodriguez et al (2013) argued that the success in building the groups of students of STEM project based learning, plays a key role in the success of the whole process. Their study result shows that the leader of each group who plays the role of coordinator. The members of the group play a significant role in their success and result in the achievement expected from each group. The study has not recommended a specific guaranteed procedure to select the group members. However, the study showed that the leadership style plays an important role in motivating group members. Weak leadership gives way to low motivation to work, as well as and gives way to weak projects in the outcome. Therefore, it is important to note that strong leadership, who gives clear roles to group members and strict rules, provides significantly better motivation, and outcomes in projects and achievement.

Bilgin, Karakuyu and Ay (2015) argued that the beliefs of students toward science was more positive when project based learning was used. Students achievement was better. The self-evaluation of students shows that self-efficacy toward science teaching have been increased. Bilgin, Karakuyu and Ay (2015) and Kunberger (2013) see that evaluation of the ongoing progress of STEM projects must be more important than the evaluation of the result in the STEM project based learning.

Munakata and Vaidya (2015) argued that STEM project based learning encourages creativity. Using open ended questions and motivating students to work in multi-disciplinary projects instead of the traditional teaching methods can encourage creativity, where students can search for solutions for the problem they face during their work. Solutions can contain unique and creative ideas that cannot be found in ordinary classes.

1.2 Background of the Research

Kunberger, T. (2013) showed that using project based learning gives result that more reasonable and most student met or exceed teachers' expectations than the normal lecture teaching in a study was conducted in high schools.

Tseng et al (2013) argue that student attitudes had significantly changed after implementing the integrated science, technology, engineering and mathematics (STEM) in a project based learning environment. Students consider STEM very useful in the real-life situations and provides more benefits to society making world more convenient with more efficiency with people jobs. Additionally, it is very helpful for their future careers. Han, S, and Carpenter, D (2014) also argued that students attitude toward STEM subjects are significantly affected after STEM project had finished.

UAE and STEM:

Almekhlafi and Almeqdadi (2010) argued that male and female teachers in UAE showed high impact of using technology in their classroom with slight differences in effectiveness, they came over the obstacles and facilitated the process for students. Professional development sessions helped teachers to prepare better practices and implement technology in classroom. Almekhlafi (2006b) claimed that students in UAE favored using the interactive multimedia program in English classes which shows interests for students in UAE to learn using technology.

Research by El Sayary (2014) argued that students in UAE who was taught using STEM project based learning had better progress in 21st century skills, such as cognitive, content, and collaborative skills. Students and teachers showed good perception of using STEM project based learning, which gives way to positive implications in students' choices for STEM careers.

Historically, the focus was always on males, more than females in the design and implementation of STEM based projects and activities. This was because they believe that males are more capable to do work that demands more physical exertion that was dependend upon the use of muscles, like engineering and technical works (e.g., Leder, 1992; Spencer, Steel, and Quinn, 1999; Watt, 2008 cited in Forgasz, Leder and Tan 2014).

Regardless, the great success obtained by many females across the world, still negative expectations from them according STEM careers and fewer candidates show interest in these careers, especially engineering (Hill, Corbett, and Rose, 2010, p. 38 cited in Forgasz, Leder and Tan 2014).

Gnilka and Novakovic (2017) argued that females have fewer ability to select STEM careers, and the demand form the market is high, to meet this demand, national efforts include parents, educators, economical and industrial sectors should be collaborated to change the negative ideas and remove the barriers so more females can enter this field.

Zaidi and Afari (2016) argued that females in UAE, showed less interest in STEM subjects comparing to the males specially in math and science. Although UAE needs local engineers from both genders to fill the vacancies required in the oil industry, producing renewable energy companies, nuclear power stations and new space projects, but the of number of females is still less than expected. UAE stakeholders are trying to collaborate to encourage females to enter this field to cover the gap in need.

Forgasz, H. Leder, G. and Tan, H. (2014) found that students and parents see males in UAE are better in mathematics than females. On the other hand, teachers as well, see that boys are better than girls in mathematics.

Aswad, N. Vidican, G. and Samulewicz, D. (2011) argued that since UAE is growing economically and moves across the knowledge- based strategies, there is a big need of the emirate manpower, men and women in fields such as science, technology and engineering. However, the real situation in the universities is that females desire to join these careers is much less than the expected. This indicated that public programs should be created to increase the interest of females toward STEM careers. Also, teaching STEM in the high school setting can be very effective in increasing the interest of females, if it is conducted in a suitable way.

1.3 Purpose and Objectives

To investigate the working model already in use in UAE, and to check to what extent that suits the nature of the community, to investigate how STEM project based learning enables students to show their interest in STEM subject and enable females to be an essential part of STEM education.

From investigating a school that contains 100% Emirati students, the good practices can be pointed out, as well as the strengths and weaknesses from the quantitative data collected from teachers and students' questionnaire, and from qualitative date collected from the interviews with teachers and students. It was concluded that it can help to point out positive practices and eliminate the negative ones. Based on the results, perceptions and recommendations, a model can be built.

This study aims to investigate implementing STEM based projects in a selective school in UAE to check the feedback from students (from grades 8 to 11) and teachers from different disciplines participating in the project. To see what is the relationship between STEM and group formation, achievement, differentiation, motivation, assessment and gender. Focusing on the following questions:

1- How was groups formed in STEM based project tasks? Does the group leader have any influence on the group? Do any other factors in group combination have effects on the outcome of the project.

2- Does STEM based projects affect student achievement?

3- Do STEM projects take in the consideration of the different abilities of different students?

4- To what extent does STEM based projects affect students' motivation to learn?

5- How are STEM based projects assessed?

6- Do genders have any effect on STEM based projects?

At the end of the study, recommendations will be designed to summarize the strengths and identify the weaknesses of the study, if any, for future consideration.

This study tries to identify the relationship between six important criteria on STEM projects, whereas previous works have focused mainly on one criteria at a time. Rodriguez Montequin et al. (2013) argued that group formation enhances the outcome of the group. Hanand and Carpenter (2014) argued that student attitudes towards STEM careers improves after applying STEM projects.

Muller (2015) supported using STEM in education to preserve a relationship between the different available disciplines, especially after the increasing gap between each discipline following the expansion of new inventions and the new divisions in each discipline. STEM also provides differentiated tasks in one integrated project.

Bilgin, Karakuyu and Ay (2015) argued that project based learning increases student achievement and positively affects student self- efficacy.

1.4 Scope of work

STEM projects are being applied in some schools across the UAE. The school under focus applies a STEM project each term. The academic year in the UAE consists of three terms. In every term in this school, students have to do one different STEM project, which is selected by the curriculum development unit in the school. Each grade level will do the same project and submit it at the end of the term. Each STEM project accounts for 10 percent of the mark weight every term.

This study uses a mixed-method design to measure the perception of STEM held by students and teachers. In the first stage, questionnaires were conducted for students, both males and females, to gather their perceptions about the STEM project they undertake every term. Similar questionnaires were conducted with teachers from different disciplines to obtain their perceptions about the STEM projects. The questionnaires included the five criteria the study focuses on. Student and teacher perceptions were then analyzed quantitatively and qualitatively. Total responses included N=187 male students and N=134 female students from one school in the UAE that apply a STEM project every term as a term based project. In addition, 66 teachers from seven disciplines participated in the project.

In addition, the perception of teachers from multiple disciplines were measured qualitatively using interviews following the initial questionnaire responses, in order to gain further insights and build a greater understanding on areas that were not clear from the questionnaire data analysis. Accordingly, the five main criteria have been put in focus in each interview. Furthermore, student perceptions have been measured during several interviews to focus on the same main items.

1.5 Structure of the Dissertation

This dissertation consists of five chapters. This chapter includes the background of the research, introduction to the study, the rationale, the importance of this study and the relationships between this study and previous relevant studies. The statement of the problem, explanation of the objectives of the study and the main questions that this study aims to answer are also included in this chapter.

In chapter 2 this study discusses the conceptual framework, definitions of STEM, a historical view of STEM, the relationships between STEM and several variables that affects and being affected by STEM, such as, project based learning (PBL), group formation and its relationship with collaborative learning, achievement, differentiation, student motivation toward STEM careers and to study in general. Two discussions are also included in this chapter covering assessment of STEM, giving examples of assessment in collaborative learning, PBL and STEM, followed by a discussion about gender effects.

Chapter 3 discusses the methodology used for data collection, as well as ethical considerations. Chapter 4 discusses quantitative and qualitative data analysis. Chapter 5 presents the discussions, conclusions, implications and the limitation of the study.

Chapter 2: Literature Review

In agreement with cognitive educators, learning new knowledge, must be based on previous knowledge which already exists, interactions between old and new knowledge will combine the new experience into a bigger one and gradually students' knowledge increases. To make this learning happen quicker, and last longer, educators advise this must occur with hands-on experience (Bilgin, Karakuyu and Ay 2015). Thus, one of the major factors of the successful implementation of STEM PBL is teachers' understanding of their role, how to prepare and introduce activities, experiments and pieces of research that are expected from students. Failing to do so, in some cases a negative impact will reflect on students' perceptions of STEM PBL (Wilhelm 2014).

When PBL is conducted through a science, technology, engineering and mathematics (STEM) background, it gives students the chance to learn in a collaborative, interdisciplinary environment away from traditional student-centred and subject-centred learning (Han et al 2015).

A recent study by Wan Husin et al. (2016) argued that 21st century skills, weather cognitive or collaborative (El Sayary 2014), such as technological literacy, communication and critical thinking, can be obtained by implementing STEM PBL.

2.1 Overview of STEM:

Capraro (2014) argued that STEM is any teaching strategy that contains the integration of any two or more fields of science, technology, engineering, and mathematics. As a result of the connection of real life and problem based learning, there are almost always two or more subject areas are included in solving these problems. Sahin et al. (2015) defined STEM relating it with problem based learning as a clear outcome with an unclear task. Wise Lindeman and McKendry (2015) claimed that STEM is not an integration of four subjects but also contains teaching practices based on constructivism and constructionism. Therefore Lewis, Capraro and Capraro (2013) argued also that STEM PBL is built on constructivism where students get the chance to work in groups cooperatively, in hands-on activities under an interdisciplinary umbrella to answer open-ended questions.

Breiner et al. (2012) claimed that STEM has more than one meaning, as the abbreviation shows; for some educators it can be different types of activities, or it can be the replacement of the normal traditional method of teaching to a new scope. Some other educators see it as just teaching interdisciplinary subjects.

Capraro (2008) claimed that STEM PBL needs students to examine the project themselves, rather than depending on the teacher to explain what they must do. However, STEM PBL is an interdisciplinary approach, and students must analyse the problem they have from different angles in order to reach the required outcome.

The best techniques to implement STEM PBL in classrooms include introducing an ill-structured task with a clear expected outcome, allowing students to work effectively in groups in an interdisciplinary approach with a variety of tasks that ensure the engagement of students with different abilities within the curriculum to reach the targeted outcome (Lewis, Capraro and Capraro 2013).

Capraro et al. (2012) argued that the implementation of STEM projects requires an effective PD, which can help teachers promote the educational objectives of STEM PBL. Thus, the level of the students' experience, which reflects on the motivation and achievement of students, depends on how well teachers understand STEM and how professionally they implement it. In contrast, unprofessional teachers will have a negative impact toward STEM and affect student attitudes and decrease their motivation. This gives the PD sessions for teachers a high priority.

Turner (2013) introduced some challenges that face STEM education, such as a lack of professional development sessions for teachers, so they will be ready to address any challenges faced in facilitating the ongoing process. Furthermore, STEM education needs funding to provide the necessary equipment and materials required for such projects.

2.2 STEM and Project based learning

Capraro, Capraro and Morgan (2013) stated that PBL has been used for a long time in many areas, such as engineering, information technology, economics and in the medical industry. Problem based learning and PBL differ in which PBL is wider containing more problems and challenges, which gives students more experience and chances to search for answers in more than one discipline. This increases self-efficacy, building new knowledge which lasts longer (Capraro, Capraro and Morgan 2013). Hence, STEM problem based learning is immersed in PBL, therefore, in this study problem based learning is considered a part of PBL.

Teaching STEM needs to have an ill-structured problem that is related to the STEM subjects and to the environment where the students live. The type of problem, and what effects it would have on students, had been the topic of notable research. Most of these studies found that relation is directly proportional between the complicity of the problem and the skills students have gained (Capraro, Capraro and Morgan, 2013; Russell, Hancock and McCullough, 2007; Hunter et al., 2007; Seymour, Hunter, Laursen, and andDeAntoni, 2004; Celia, 2005; Lopatto, 2004; Bauer and Bennett, 2003; Zydney, Bennett, and andShahid, 2002a; Zydney, Bennett and andShahid, 2002b).

2.3 STEM and Group Formation

When students work in groups, there are more chances for them to develop a variety of skills and abilities, such as critical thinking, intrapersonal and interpersonal intelligence, collecting and analysing data and communication skills. Furthermore, this provides the opportunity to accept other people's ideas and being an effective team member and having a chance to be a team leader, also problem-solving techniques. All of this will improve the educational outcome (Sofroniou and Poutos 2016).

"The belief that learning is a sociocultural and co-constructed activity" (Guyotte et al. 2015; Vygotsky, 1978) was adapted in many articles to encourage the use of cooperative learning in classrooms. STEM PBL has a base which is built on cooperative learning, where students in groups, work, interact and develop their sociocultural skills, communication and problem-solving skills (Guyotte et al. 2015).

Kyprianidou (2012) argued that heterogonous group formation raised students' productivity in the groups. Furthermore, students became more aware about themselves and other group members, which means they also earned sociocultural skills.

Raiyn and Tilchin (2016) argued that self-formation groups constructed by students could achieve better results in the assessment when the group finish the required task, because of sharing accountability where all students feel himself (herself) responsible for the group result. Furthermore, this could encourage students to a higher order of thinking, because each group member is accountable for the final score.

Navarro et al. (2012) argued that the process of dividing students into groups plays an important role in the success of cooperative learning. Groups can be homogenous, which means students with the same level of proficiency in one group, or heterogeneous or mix ability groups, in which work can be divided based on students' abilities and preferences. Therefore, some students like to divide groups based on friendship, so they can work more comfortably.

2.4 STEM and Achievement

Based on the results of several studies on the significant difference between students who use STEM PBL and students who study the same material at the same time with the traditional teaching methods, they found that PBL gave more self-capability toward learning science, and students' results improved compared to the normal teaching method (Bilgin, Karakuyu and Ay 2015). Hathcock et al. (2015) argued that ill-structured problems, like those in STEM and inquiry, give fantastic opportunities for students to search for solutions showing their creativity to give unique answers to these problems. However, the skill used to introduce those ill-structured questions plays a key role.

Nelson et al. (2011) argued that the averages of students who graduated from STEM schools are higher than the averages of students who graduated from non-STEM schools. While an earlier study by Nelson et al. (2008) demonstrated that non-STEM schools include higher implementation of high order thinking and students earn higher cognitive levels than students in STEM schools. A later study showed that the professional development sessions, which are held for teachers to train them in how to implement STEM project teaching in a way to give higher cognitive levels, and high order learning were effective, and teachers recommended these to be regular. Han (2015) mentioned another motivation to implement STEM projects at school, which is the sociocultural effects on students' attitudes and behaviours, students cooperatively work in groups discussing decisions, which helps them to reach social maturity.

2.5 STEM and Differentiation

Working in groups focuses students in working towards achieving success for all group members, which a creates competitive atmosphere (Rodríguez et al. 2013). Furthermore, group work can be divided into different approaches, each of which can favour the different learning styles of students, with above average students preferring to work homogeneously, while on or below average students prefer heterogeneous grouping (Han, 2015).

Many factors may affect differentiation, which is providing suitable activity to each student based on his or her skills and capabilities (Bilgin, Karakuyu and Ay 2015). Other than the cognitive level of each student and the different abilities of each individual, school environment, parents, community and content are all factors that must be taken into consideration in designing STEM differentiated interdisciplinary projects (Capraro et al. 2016).

It is not possible to guarantee a perfect method to address each student's diverse learning strengths and needs and create opportunities for students to demonstrate their learning in different ways. Variations in teaching and learning activities must be used to develop learner skills. Moreover, activities must involve the whole group, small groups and individual students. Creating this diversity in classrooms increases the level of motivation and achievement for students, and other factors affecting expectations and achievement (Han et al. 2015).

Han, Capraro and Capraro (2015) argued that student achievements measured by math scores in an implementation of a STEM interdisciplinary project was below the earlier expected rate. The study recommended more trials of creating effective differentiated STEM activities that address each student based on their ability and keeping them engaged. More guidance for teachers to create these activities is needed. The study showed different achievement rates for different groups of students; with above average students increasing in achievement rate differing from on average or below average students. This means a unique teaching environment needs to be developed to address each student's learning style.

STEM PBL is wider than problem based learning as the former contains more and wider open-ended problems to be investigated and solved by students (Capraro, Capraro and Morgan 2013). Furthermore, STEM PBL includes a variety of components, such as the cooperative learning, the hands-on activities, the ill-structured tasks, and work under the pressure of time, some components are suitable for groups of students and not for others, which give opportunities for students with different abilities to find the type of work that best fits their abilities (Han and Carpenter, 2014)

2.6 STEM and Motivation

Tseng et al. (2013) mentioned that STEM PBL more positively encourages achievement than the academic performance. With a comparison to students who took the traditional teaching methods, students who have finished the term using STEM PBL showed more motivation toward learning, more discipline in the cooperative groups and more communication skills. Furthermore, STEM PBL has showed a noticeable increase in students' self-confidence and productivity.

Wilhelm (2014) argued that STEM PBL can influence student achievement in mathematics, and can increase their understanding. Han (2013) argued that after using STEM PBL, not all students reach the same level of achievement, instead, below average students showed less improvement in their academic achievement, while above average students showed better improvement in their achievement. The study also showed another factor, which could affect the academic achievement of students, such as gender, English language proficiency and community effects.

Yoon (2009) preferred student-centred learning in a collaborative environment rather than the traditional method for above or average students. Here, Yoon found students to be more self-directed, while the teacher is to give support, guidance and formative feedback to the students in a motivated learning environment. This gives the chance for students to put all their efforts to reach the high expectations from teachers. This will definitely increase students' achievements. While below average students are less self-directed learners, and they have less motivation to learn, they often get bored and off task if they were not under constant supervision. Furthermore, in order for these students to achieve more, teachers must conduct more interventions, and they need to attend more PD sessions about implementing the best techniques in teaching STEM PBL (Lewis, Capraro and Capraro 2013). On the contrary, Han (2013) argued that STEM PBL in a student-centred environment has a more positive influence on below average students' achievements in mathematics classes. The above average group, as well, displayed a positive increase in achievement but less in comparison with that for the below average group.

Han (2014) claimed that the achievement of students would be affected by two important factors: 1) the environment of learning, which is the STEM PBL, and 2) the students' capabilities, which divide into many other sub-factors. Thus, students' achievements significantly increases if the learning environment is STEM PBL.

2.7 STEM and Gender

If we look at the history of STEM disciplines we will notice that it has been considered as a male sector gender pattern. This is largely due to the fact that males are perceived as being more capable to work in these areas such as engineering and sciences (e.g., Leder, 1992; Spencer, Steeland and Quinn, 1999; Watt, 2008 cited in Forgasz, H. Leder, G. and Tan, H 2014).

Negative perceptions often persevere regarding female students' abilities to work in STEM subjects, even though many girls and women across the world have had great success in this field. Nonetheless, beliefs persist that male students are trusted more in STEM fields, especially in engineering and science (Hill, Corbett and Rose, 2010, p. 38 cited in Forgasz, H. Leder, G. and Tan, H 2014).

Gnilka and Novakovic (2017) argues in their study that females still have less ability to choose STEM careers. To remove the barriers around STEM careers for female students, an intervention must be prepared to increase the beliefs about STEM careers. School counsellors, teachers, parents and the broader community must take the responsibility to reduce the barriers for female students to pursue STEM careers.

Zaidi and Afari (2016) argued that there is a huge gap in the UAE between males and females toward the perception of STEM subjects, especially math and science. Even though the UAE is an oil-dependent country, this industry is considered to be the first, in addition to the need for engineers from both genders to run the renewable energy projects, including nuclear projects, and space projects. Therefore, there is a huge need of engineering to fill these sectors. The UAE is trying to encourage both genders to enter the STEM field and to supply a sufficient flow of capable graduates.

Forgasz, Leder and Tan (2014) argued that students and parents perceive that 35.3% males in the UAE are better in mathematics than females, comparing to 11.8% who believe that females are better. On the other hand 48.4% of teachers see that boys are better compared to 6.6% who see that girls are better.

Aswad, Vidicanand and Samulewicz (2011) argued that as the UAE is growing economically and progresses with its knowledge-based strategies, there is a huge need for STEM professionals. However, the real situation in the universities is that female students are far less inspired to join STEM fields than expected. This indicated that public programmes should be created to increase the interest of females toward STEM careers. Teaching STEM in high schools can be very effective in increasing the interest of female students if it is conducted in a suitable way.

For instance, studies showed that achievement marks were different for female and male students who were in the same learning environment, with the same teachers and same textbooks (Benbow, 2012; Matteucci and Mignani, 2011).

For example, student scores indicated important differences by gender; however, the difference in mathematics was smaller than in other subjects, i.e., science, reading and writing (Konstantopoulos, 2009; Ma and Klinger, 2000; Shores et al., 2010). In contrast to the conventional gender preference opinion mentioned above female students preferred STEM PBL type activities and demonstrated higher achievement in Boaler’s study (1997).

Chapter 3: Methodology

STEM education has gained the interest of many educators in the 21st century. The national initiatives in the UAE encouraging innovation in STEM has increased in the past few years. This has involved encouraging schools to implement STEM projects as implementing STEM projects has many goals, such as providing students with skills they need to succeed in their future careers. This includes problem solving, good communication skills, real-life problem solving, critical thinking and inquiry. For successful implementation of STEM in schools in the UAE, first, educators must know the perceptions of current implementations.

This piece of research was carried out during term 2 of the academic year 2016-2017 in a selective semi-government school in the UAE that teaches applied engineering and technical subjects. STEM projects are offered every term in this school, taking 10% of the subject weight. Subjects that participate in STEM are: sciences (physics, chemistry and biology), mathematics, applied engineering, computer science, English language, Arabic language and arts. Term 2 in this school lasts from January 5th until March 23rd. The study focuses on investigating the perceptions of students and teachers of five items, group formation, motivation, achievement, differentiation and assessment. Furthermore, the study focuses on any gender differences between students according to the perception of the above factors. Previous studies focused on one of the above factors at a time (Sofroniou and Poutos 2016). Accordingly, this research has recommended multiple criteria to measure perceptions, which requires multiple measures (Raiyn and Tilchin 2016).

Thus, more than one instrument is designed to be used in this study. First, a student's questionnaire was used to measure students' perceptions and feedback about the five factors. Then another questionnaire was used to measure teachers' perceptions about the same factors. This data was then analysed, means and standard deviation were measured, and a t- test was conducted to measure any significance. Then individual interviews were conducted with students and teachers to further explore their perceptions of factors that did not show significance on the questionnaires.

3.1 Research Design

A mixed method design is used to investigate the perception of the effects of group formation on STEM, the effect of STEM on motivation and achievement, how STEM is being assessed and the gender perception differences according to the five previously mentioned factors (Han, 2013; Hathcock et al. 2015; Raiyn and Tilchin 2016).

This study was designed to contain several tools to measure the perception of teachers and students about how STEM affects achievement and motivation (Rennie, Venville and Wallace 2012) to select STEM careers in the future (Riegle-Crumb, King, Grodskyand and Muller 2012; cited in McDonald 2016), to check how group formation affects the outcome of STEM project (Rodríguez et al. 2013), to check the perception about assessing STEM projects, what differentiated practices have been used to teach STEM and how STEM has helped differentiating (Bilgin, Karakuyuand and Ay 2015; Kunberger 2013). Furthermore, this study aims to identify the gender perception differences (Gnilkaand and Novakovic 2017). This is done to understand the perception of teachers and students regarding these factors.

Creswell (2008) advocates gathering multiple data and compiling them together depending on pragmatism philosophy. Johnson and Christensen (2012) suggested the use of both quantitative and qualitative methods. This allows the researcher to cover all topics to give a better view of the study.

The research study is conducted in two consecutive levels. The first level is collecting quantitative data. By using questionnaires for teachers to measure the perception of the five factors. Further questionnaires was sent to males and females students to measure their perception about the same factors, which were sent after the submission of STEM projects, so the effect of STEM projects -if any- on motivation and achievement should appear (Muller 2015). The second level is collecting quantitative date which was done by conducting interviews with both teachers and students over a 3 week period.

Figure 1 below shows the progress levels of the data collection

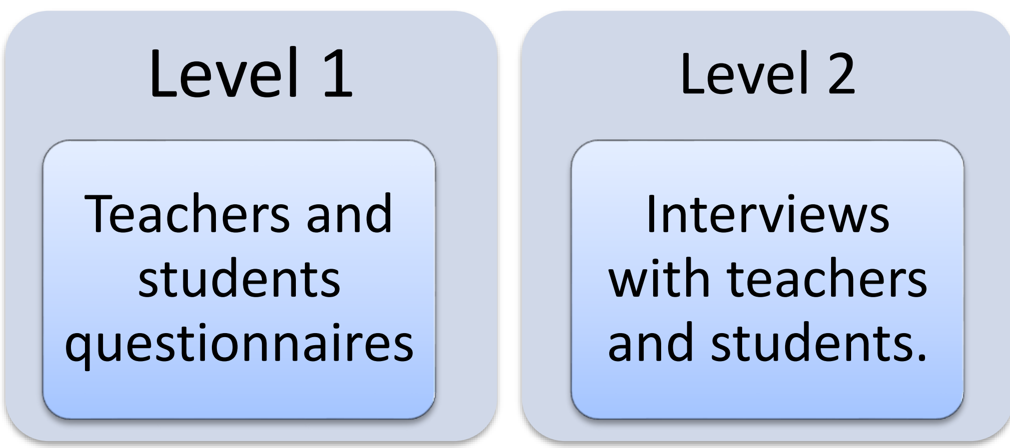

Figure 1 The Two Levels of the Study

3.2 The Population of the study

The population of the study includes the whole accumulation of people who were chosen by the researcher to participate in the study (Dick 2004).

The participants of this study are divided into three groups. Group 1 is: teachers (N(1)=66) from one school in the UAE which adapts STEM projects as term projects which take 10% of the mark weight of each subject. Teachers are distributed as follows: English teachers: 16, science: 16, mathematics: 14, applied engineering 9, computer science: 5, Arabic and Islamic: 5 and arts: 1 teacher only. Group 2 is: male students from grade 8-11, (N(1)=186). Group 3 is: females from grades 8-11 (N(1)=134). The study investigates the perception of teachers and students (males and females) according the effect of group formation on STEM, the effect of STEM on achievement and motivation, how STEM is assessed and the mutual effects between differentiation and STEM. A STEM project is taught for students from grades 8-11 who have participated in this study.

3.3 The Samples Selected

The sample of this study is one school that was chosen from 10 campuses distributed in the seven emirates. The school is considered to be representative; a non-probability selection makes the sample more effective (Kalton 1983). The participants are teachers of science, technology, engineering and mathematics (STEM) plus teachers of English, Arabic and arts with a total number: (N(1))=66, and male students (N(1)=186), and female students (N(1)=134). All students were from grades 8-11.

3.4 Instrumentation

Multiple tools are used in this study. The study is divided into two levels of implementation, the first level is the quantitative data collection conducted by using questionnaires: for teachers, male students and female students. These questionnaires were distributed using google forms. And sent to teachers and students via email to register their responses about the perception of STEM project on field of the study: the effect of group formation on STEM, the effect of STEM on achievement and motivation, how STEM is assessed and the mutual effects between differentiation and STEM. Next, after the data analysis was complete, interviews were conducted with teachers and students to fill the gap that was expected to appear from the questionnaire to clarify the ambiguity about teachers' and students' perceptions.

3.4.1 Teacher Questionnaire

The teacher questionnaire was designed to answer the five research questions, which are: How have groups been formed? Does the group leader have any influence on the group? Do any other factors in the group combination have effects on the final outcome of the project? Does the STEM project affect the students' achievements? Does the STEM project take into consideration the different abilities of different students? To what extent does the STEM project affect students' motivation to learn. How is the STEM project assessed?

The questionnaire started with an introduction paragraph about the questionnaire, followed by questions about the teacher's subject and classes (Turner 2013). The questionnaire the was divided into five parts: group formation (3 questions), motivation (2 questions), achievement (2 questions), differentiation (3 questions) and assessment (5 questions).

The questions of the questionnaire presented the following possible answers: strongly agree (5), agree (4), I don't know (3), disagree (2) and strongly disagree (1).

The questionnaire was collected from several studies. Turner (2013) claimed that a questionnaire is an effective method to collect the perception of STEM implementation. Han, Capraro and Capraro (2015) recommended that investigating the effects of STEM projects on achievement, motivation and differentiation should be conducted on a long-time frame study to measure the expected change. However, this study focuses on measuring the perception of implementing STEM projects, rather than measuring the change in achievement. Thus, questionnaires are used to investigate perceptions. Bozkurt Altan and Ercan (2016) depended on the qualitative method in investigating the perception of implementing STEM projects from teachers. In this study, a mixed method using both qualitative and quantitative methods is used (Tseng et al. 2013).

The teachers' questionnaire was divided into six parts; the first part is an introduction about the questionnaire, about the teachers' subject and the grades he/she teaches. Each other part of the questionnaire was designed to measure the perception of one factor. The first part was to investigate the perception of the effect of group formation. The first question asks if the groups were chosen randomly; the second question asks if the groups were built based on students' abilities; while the third question asks about the perceptions of teacher's about the effect of group leaders' abilities to enhance the work of the groups. The second part of the questionnaire is about motivation and consists of two questions: the first asks if the teacher believes that STEM projects increase the motivation of students to study. The second question measures the perceptions of teachers if they see that a STEM project increases the motivation of students to choose STEM majors in their university studies in the future. Part 3 of the questionnaire was about achievement and consists of two questions, the first asks teachers if STEM projects affect the marks of students. The second question asks if students become more able to find the knowledge they need after completing a STEM project. Part 4 of the questionnaire explores differentiation and consists of three questions; the first checks if teachers perceive that STEM gives every student the tasks he/she is good at. The second checks if teachers distribute the tasks based on students' abilities. The third question asks about teachers' perceptions about the hardness and suitability of STEM projects to students' abilities. The last part of the questionnaire is investigates assessment; the first question asks if teachers see the assessment process as fair. Second question checks if teachers give the same mark for all students in the group regardless of their role in the group. The third checks if the same marks of the STEM subject were given for each group. The forth checks if the assessment is summative and the last checks if the assessment is formative. The questionnaire responses were collected at the end of term 2, using google forms. The link was sent to all teachers via email by the academic vice principal after obtaining the director's approval.

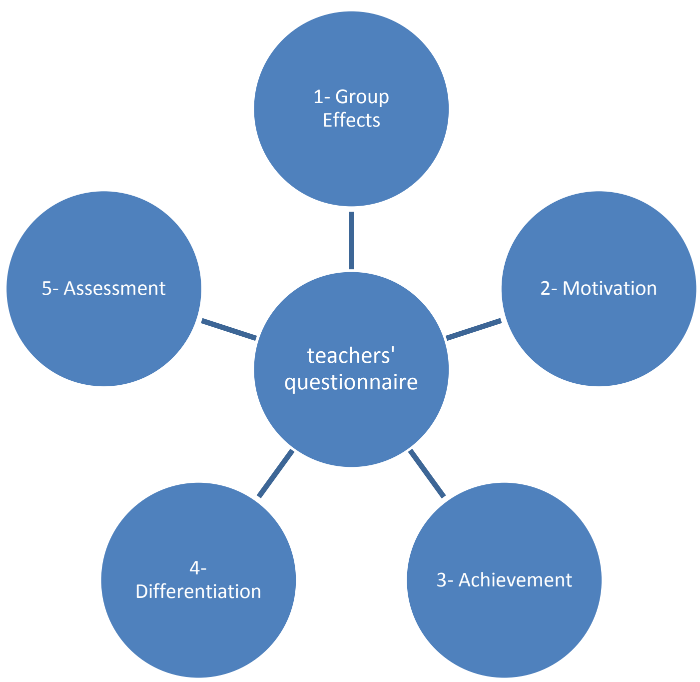

Figure 2 The five main areas of the questionnaire

3.4.2 Description of the STEM Project used in the Selected School

The selected school divides into two different streams, the applied technology school and the technical school. Both offer STEM project every term in the academic year which consists of three terms in the UAE; each term extends from 10-14 weeks. The targeted students for THE STEM project are students from grades 8-11 in the applied technology school, and for grades 10-11 in the technical school. The topics of THE STEM project during terms 1 and 2 in the schools are listed in table 1 below:

	Term 1 projects	Term 2 projects
Grade 8 Applied Technology	The Kite	Homopolar Motor
Grade 9 Applied Technology	Wind Chime	Water Filter
Grade 10 Applied Technology	Simple Machines	Artificial Arm
Grade 11 Applied Technology	Crossing the River: Popsicle Stick Bridge	Tennis Ball Launcher
Grade 10 Technical	Build a Geodesic Dome	Maglev Train- The Hyperloop
Grade 11 Technical	Create a Wind Turbine	Roller Coaster

Table 1 STEM topics in the school

Each class has a teacher who coordinates the progress of undertaking the project. This teacher divides the groups, and follows-up with other teachers, organizes teachers' meetings to discuss student progress and difficulties of each group. Each subject teacher introduces the project from the subject point of view, discusses the project objectives, the challenges that students may face and guides them towards possible resources to face these challenges. The teacher also discusses the minimum level accepted from students, as well as the marking rubrics. Thus, each student should know exactly what is required from them, and knows the assessment rubrics for each subject.

3.4.3 Students' Survey

The questionnaire that have been used to collect students' responses are a combination of multi-questionnaires used separately to use the perceptions of students in different places. Rodríguez et al. (2013) argued that the success in building groups is the first step of success in a STEM project. Bilgin, Karakuyu and Ay (2015) argued that student achievement and motivation increased after completing interdisciplinary STEM projects. Kunberger (2013) recommended continuous evaluation of STEM projects and not to evaluate the whole process only after the students have completed their projects. Forgasz, Leder and Tan (2014) argued that there is historical difference between males and females toward selecting STEM careers, where males are more likely to select STEM careers than girls. Therefore, this study contains male and female students to check if there is any significance between males and females in this school with regards to their motivation and achievement toward STEM projects in the UAE, which reflect the selection of STEM careers in the future (Zaidi and Afari 2016). The questions mostly developed from the National Science Foundation Student responses were measured by Likert-scale questions from 1-5 (1 Strongly disagree to 5 Strongly agree). Students were asked to respond to the questionnaire at the end of term 2 after they have submitted their projects. The questionnaire responses were collected at the end of term 2, using google forms, the link was sent to all students via email by the academic vice principal after obtaining the director's approval.

3.4.4 Teachers' Survey

After finishing the data analysis, some gaps appeared. The need to uncover the enigma behind these gaps led to the use of interviews was used to help several teachers and students to focus on the following questions:

1. What is STEM?
2. What are the preferable techniques to implement STEM in your classroom?
3. How do think professional development regarding implementing STEM would affect its effectiveness?

3.5 Data Collection Method

Before the end of term 2 after students have completed their STEM projects, teachers' questionnaires were sent to them via email to collect their perceptions about the five factors: grouping, achievement, motivation, differentiation and assessment. Ethics were considered while asking teachers' permission to share in the study. Participating in this questionnaire was not compulsory, teachers were not asked to write their names, just their departments. Information collected was private and confidential and used for the purpose of the study only. The collection of teachers' responses took around one week to give sufficient time for all teachers to respond to the email sent.

The following week, the students' questionnaire was sent to male and female students in the schools. A link was sent via email to respond to the questions on google forms. Students were not asked to write their names on the responses, only their grade level, a link was sent to male students and another link containing the same questions were sent to the female students to have more accurate results and make it easy to follow-up with the responses. Ethics were considered, and students were asked about their participation in the study. All data were kept confidential and students were not asked to write their names on the questionnaire.

The second stage of collecting data included conducting interviews. After the data analysis was completed, some gaps appeared. The need to fill the gaps required interviews of both teachers and students. Teachers were selected randomly from different STEM fields, permission from the administration and teachers to conduct these interviews was taken in advance. Interviews included open-ended questions where teachers talk about their experiences of teaching STEM projects at the beginning, then specific questions were presented to the teachers and their responses were registered.

Further interviews were then conducted with students from different levels from grades 8-11, wherein students from different categories were chosen, including high achievers, medium achievers and low achievers. Students were given the chance to speak about their perceptions of STEM projects at the beginning of the interview. Questions about the effects of group formation on the final STEM project outcome, motivation and achievement were asked.

3.6 Validity and Reliability of the Study

The questionnaire items and questions were adopted from previous literature, with some modifications applied. Thus, to ensure the validity in this research, the questionnaire was pretested with educational experts, interested parties and teachers, in order to ensure that all errors have been reduced.

3.6.1 Construct validity – The Exploratory Factor Analysis (EFA):

The Exploratory Factor Analysis (EFA) with the varimax rotation method is used to assess the construct validity. To ensure that all items were loaded onto one factor with factor loadings above 0.40 for all within-scale items and an Eigen value greater than 1. To ensure the appropriateness of factor analysis, a Kaiser-Meyer-Olkin (KMO) test for assessing sampling adequacy was carried out (Hair et al. 2009). Moreover, a Bartlett's test of sphericity to test homogeneity of variances was performed. The results show that the KMO statistic for all scales was greater than 0.50 and Bartlett's test of sphericity statistics were statistically significant ($p < 0.05$) implying the appropriateness of factor analysis.

3.6.2 Construct Validity

To ensure that the selected items are reliable indicators of their constructs, factor analysis was carried out with principal components analysis (PCA) as the extraction method. PCA was selected as it is preferred for purposes of data reduction. The goal of PCA is to extract maximum variance from the data set with each component (Tabachnick and Fidell 2001). The purpose of this is to perform within scale factor analysis to verify that all items are loaded onto one factor. Only items that had a factor loading of at least 0.40 and an Eigenvalue of at least 1 were retained (Hair et al. 2010). Two items did not meet this criteria as their loadings were below 0.40 and were deleted. The results of the factor analysis are reported in tables 2 to 6 below.

Table 2 below shows factor analysis for achievement. The two items related to achievement were loaded onto one factor with factor loadings greater than 0.40. the Eigenvalue for this construct is 1.605, which is greater than 1.0. The proportion of variance explained is 80.234%.

Scale	Achievement		
Factor loading	Factor 1	Factor 2	Factor 1
Question 1	0.896		
Question 2	0.896		
Eigenvalue	1.605		
Proportion	80.234%		

Table 2 Factor analysis for achievement items

Table 3 below shows factor analysis for group formation. The three items of group construct were loaded onto one factor; however, the factor loading of item 3 was less than 0.40 and, therefore, the item was deleted. The Eigenvalue for this construct after the deletion of item 3 is 1.359 and the proportion of variance explained is 67.959.

Scale	Group		
Factor loading	Factor 1	Factor 2	Factor 1
Question 1	0.822		.824
Question 2	0.812		.824
Question 3	-0.186		Deleted
Eigenvalue	1.369		1.359
Proportion	45.623%		67.959

Table 3 Factor analysis for group items

Table 4 below shows factor analysis for motivation. The two items related to motivation were loaded onto one factor with factor loadings greater than 0.40. The Eigenvalue for this construct is 1.558, which is greater than 1.0. The proportion of variance explained is 77.879%.

Scale	Motivation		
Factor loading	Factor 1	Factor 2	Factor 1
Question 1	.882		
Question 2	.882		
Eigenvalue	1.558		
Proportion	77.879%		

Table 4 Factor analysis for motivation items

Table 5 below shows factor analysis for differentiation. The three items of differentiation construct were loaded onto one factor; however, the factor loading of item 3 was less than 0.40 and, therefore, the item was deleted. The Eigenvalue for this construct after the deletion of item 3 is 1.522 and the proportion of variance explained is 76.079.

Scale	Differentiation		
Factor loading	Factor 1	Factor 2	Factor 1
Question 1	.821		.872
Question 2	.825		.872
Question 3	-.586		Deleted
Eigenvalue	1.698		1.522
Proportion	56.615%		76.079

Table 5 Factor analysis for differentiation items

Table 6 below shows factor analysis for assessment. The five items related to assessment were loaded onto one factor with factor loadings greater than 0.40.

the Eigenvalue for this construct is 2.253, which is greater than 1.0. The proportion of variance explained is 45.051%.

Scale	Assessment		
Factor loading	Factor 1	Factor 2	Factor 1
Question 1	.738		
Question 2	.687		
Question 3	.585		
Question 4	.658		
Question 5	.652		
Eigenvalue	2.253		
Proportion	45.051%		

Table 6 Factor analysis for assessment items

3.6.3 Reliability of the Study

Cronbach's coefficient α, a widely used indicator for assessing internal consistency of scale variables, is used to evaluate the reliability of the study constructs. Generally, the recommended standard to consider the scale as internally consistent is $\alpha \geq 0.70$ (Nunnally 1967). However, Nunnally recommends a minimum standard of $\alpha \geq 0.60$ for newly developed scales. The alpha coefficient for the group category construct was below 0.60 with a value of 0.523, as shown in Table 7 below.

category	**Cronbach's alpha**
Group	0.523
Achievement	0.752
Motivation	0.716
Differentiation	0.683
Assessment	0.692

Table 7 Cronbach's alpha coefficients

3.7 Ethical Considerations

Differentiating between the two terminologies of morality and ethics is remarkably important. Morality and ethics are defined as “the philosophical study of morality” (Vaughn 2010, P.3). Though, Morality in the beliefs, concepts, values, principles or limitations are concerned with what is true and what is wrong, what is proper and what is improper (Vaughn 2010, P.4). Particularly, we are ethical because the community forces act in a particular way and follow certain rules. However, we are practicing morality because we consider that something is bad or good. Bell (1999) argued that the researcher cannot find an excuse not to take ethical consideration during his study. In this study, ethics has been taken into consideration based on Hart’s ethical principles (2005); probity, competence, human rights, social liabilities and scientific responsibility.

First, participants in the questionnaire were informed about the study purpose, and they were given the choice to participate or not. Participants included teachers and students, both males and females. The total number of male students was 186, which was around 50% of the total number of students. Participants’ privacy and confidentiality was assured, with no names recorded.

The next chapter proceeds to present the data analysis, the findings, and the discussions that have arisen from this mixed-methods research study.

Chapter 4: Analysis of Data and Results

The main purpose of this study is to investigate the perceptions of students and teachers regarding implementing STEM projects, and focus on the main strengths and weaknesses in students' and teachers' perspectives and compare it with literature and write recommendations to be used in future implementations. The study focuses on six main categories: group formation, achievement, motivation, assessment, differentiation and gender differences. The study contains quantitative and qualitative parts: first, the quantitative section included distributing questionnaires to teachers, male students and female students. Responses were collected and analysed. Then interviews were conducted with teachers and students to qualitatively fill the gaps that appeared in the questionnaire results.

4.1 Students' questionnaire t-test analysis

A T-test was conducted three times for the students' questionnaire, first a T-test for all items was conducted. Then a separate single T-test for each category was conducted. The last T-test was conducted to compare the perceptions of male and female students regarding the five categories. The details are explained below.

4.1.1 One sample t-test for all items in students' questionnaire

A quantitative nonexperimental questionnaire study was used to provide the most in-depth understanding of the perception of implementing a STEM project in a selective school from grades 8-11 in the UAE. A series of one sample T-tests was used to answer research questions 1, 2, 3, 4, and 5. Single sample T-tests were used to determine statistical significance comparing the means with 3, representing neutrality for research questions 1, 2, 3, 4, and 5. Data were analysed at the 0.05 level of significance. The Statistical Package for the Social Sciences (SPSS) was used for data analysis. Google forms were used to calculate data that was used for analysis. Descriptive statistics were also used to summarise additional insights into questions 1, 2, 3, 4, and 5. Interviews with students were conducted after completing the analysis, to fill the gaps that appeared toward the insignificance in achievement and assessment perceptions; answers were collected and identified then recorded for frequency.

The results from the questionnaire revealed that there is a significant difference for the overall (all the items together) construct with t = 2.411, which indicates that the difference was statistically significant as the t value exceeded the tabulated t value t (96) = 1.99. The probability value for this domain was 0.016, which is less than α=0.05 confirming that there is a significant difference. The mean was 3.11 with a standard deviation of 0.838, as shown in table 8 below:

Category	Mean	SD	t-value	P-value
Overall construct	3.11	.838	2.411	0.016

Table 8 One sample T-test of overall construct

4.1.2 One sample T-test for each category in the students' questionnaire

1-groups formation

One sample T-test was conducted to test whether or not any significant differences exist regarding the group category. The statements were:

1- The leader gives the group enthusiasm to work better.
2- We had the freedom to build our group the way we wanted.

3- If my group was different the project would be better.

The results from the analysis revealed that there is a significant difference for the group category construct with t = 6.620, which indicates that the difference was statistically significant as the t value exceeded the tabulated t value t (96) = 1.99. The probability value for this domain was 0.000, which is less than α=0.05 confirming that there is a significant difference. The mean was 3.414 with a standard deviation of 1.118, as shown in table 9 below:

2 -Achievement

One sample T-test was conducted to test whether or not any significant differences exist regarding the achievement category. The statements were:

1- Doing STEM project increased my motivation to study.
2- After doing STEM project I have the desire to choose an engineering, science, math or technology major in the university.

The results from the analysis revealed that there is no significant difference for the achievement category construct with t = 0.182, which indicates that the difference was statistically insignificant as the t value was less than the tabulated t value t (96) = 1.99. The probability value for this domain was 0.855, which is more than α=0.05 confirming that there is no significant difference. The mean was 3.010 with a standard deviation 1.072, as shown in table 9 below:

3 -Motivation

One sample T-test was conducted to test whether or not any significant differences exist regarding the motivation category. The statements were:

1- My marks become better after doing a STEM project.

2- I am more capable to find the information I need in any subject after doing a STEM project.

The results from the analysis revealed that there is a significant difference for the motivation category construct with -3.018, which indicates that the difference was statistically significant as the t value exceeded the tabulated t value t (96) = 1.99. The probability value for this domain was 0.003, which is less than α=0.05 confirming that there is a significant difference. The mean was 2.792 with a standard deviation 1.231, as shown in table 9 below.

4 -Differentiation

One sample t-test was conducted to test whether or not any significant differences exist regarding the differentiation category. The statements were:

1- STEM project gives every student the task he is good at to do.
2- My part in the group in STEM project fits my abilities.
3- STEM project was very hard and undoable.

The results from the analysis revealed that there is a significant difference for the differentiation category construct with 5.106 which indicates that the difference was statistically significant as the t value exceeded the tabulated t value t (96) = 1.99. The probability value for this domain was 0.000 which is less than α=0.05 confirming that there is a significant difference. The mean was 3.314 with standard deviation 1.100 as shown in table 9 below.

5 -Assessment

One sample T-test was conducted to test whether or not any significant differences exist regarding the assessment category. The statements were:

1- Assessment of the project was fair.
2- All teachers gave me the same mark.
3- All group members took the same mark.
4- Teachers assessed our project only after we finished.
5- Teachers gave us ongoing assessment after each step of the project.

The results from the analysis revealed that there is no significant difference for the assessment category construct with t = 0.831, which indicates that the difference was statistically insignificant as the t value less than the tabulated t value t (96) = 1.99. The probability value for this domain was 0.406, which is more than α=0.05 confirming that there is no significant difference. The mean was 3.034 with a standard deviation of 0.731, as shown in table 9 below.

Category	**Mean**	**SD**	**t-value**	**P-value**
Group	3.414	1.118	6.620	0.000
Achievement	3.010	1.072	0.182	0.855
Motivation	2.792	1.231	-3.018	0.003
Differentiation	3.314	1.100	5.106	0.000
Assessment	3.034	0.731	0.831	0.406

Table 9 One sample T-test of the group

4.1.3 Independent sample T-test to compare male and female students

An independent samples T-test was used to explore whether or not males and females differ regarding the five categories: achievement, group, motivation, differentiation, and assessment. It was found that there is a significant difference between males and females concerning achievement, motivation and assessment. For achievement, the table below shows that the t-value is = 4.688, which indicates that the difference was statistically significant between the two groups for this category as the t-value exceeded the tabulated t value t (96) = 1.99. The probability value for this domain was 0.000, which is less than α=0.05, confirming that there is a significant statistical difference between the two groups.

For motivation, the table below shows that the t-value is = 4.165, which indicates that the difference was statistically significant between the two groups for this category as the t-value exceeded the tabulated t value t (96) = 1.99. The probability value for this domain was 0.000, which is less than α=0.05, confirming that there is a significant statistical difference between the two groups.

For assessment, the table below shows that the t-value is = 2.329, which indicates that the difference was statistically significant between the two groups for this category as the t-value exceeded the tabulated t value t (96) = 1.99. The probability value for this domain was 0.020, which is less than α=0.05, confirming that there is a significant statistical difference between the two groups.

No significant differences were found between the two groups concerning differentiation and group formation categories. For differentiation the table below shows that the t-value is = 1.453, which indicates that the difference was statistically insignificant between the two groups for this category as the t-value was less than the tabulated t value t (96) = 1.99. The probability value for this domain was 0.147, which is more than α=0.05, confirming that there is no significant statistical difference between the two groups.

For group formation the table below shows that the t-value is = -1.320, which indicates that the difference was statistically insignificant between the two groups for this category as the t-value was less than the tabulated t value t (96) = 1.99. The probability value for this domain was 0.188, which is more than α=0.05, confirming that there is no significant statistical difference between the two groups.

Domain	**Gender**	**Mean**	**SD**	**t-value**	**P-value**
Achievement	Males	3.24	1.009	4.688	0.000
	Females	2.69	1.077		
Motivation	Males	3.02	1.141	4.165	0.000
	Females	2.46	1.279		
Assessment	Males	3.11	0.778	2.329	0.020
	Females	2.92	0.648		
Differentiation	Males	3.38	1.067	1.453	0.147
	Females	3.20	1.139		
Group	Males	3.34	1.087	-1.320	0.188
	Females	3.51	1.157		

Table 10 T-test of differences between males and females

4.1.4 Students' regressions

Multiple regression is used to explore the effect of three categories, group formation, assessment, and differentiation on achievement, as shown in Table 11 below.

Coefficient of determination, R^2, shows that 35.1% of the variance in achievement is explained by the three categories. The adjusted R^2 of 0.345 indicates that the R^2 is slightly decreased due to the number of independent variables and the sample size. The F-value of 56.966 is significant ($P < 0.001$) indicating that there is a significant positive impact of the three categories together on achievement. As for the individual contribution of the three categories, the results show that all the three categories are significantly and positively related to achievement.

Variables	**Coefficients**	***P*-value**
Constant	-.027*	0.912
Assessment	0.402	0.000
Differentiation	0.166	0.003
Group formation	0.143	0.006
R	0.592	
R^2	0.351	
Adj. R^2	0.345	
F	56.966	0.000

Table 11 Multiple regression analysis on achievement

Note: *: Unstandardized Coefficient

4.1.5 Students' questionnaire descriptive statistics

The students' perception descriptive statistics by category was measured. The highest mean is group formation and the lowest is motivation 2.79.

category	Mean	SD
Achievement	3.01	1.072
Group	3.414	1.118
Motivation	2.79	1.231
Differentiation	3.314	0.749
Assessment	3.03	1.100

Table 12 Students' perception descriptive by category

4.2 Teachers' questionnaire analysis

A T-test was conducted for the teachers' questionnaire, and a T-test for all items was also conducted. Regressions were then conducted to measure the effect of group formation, assessment and differentiation on achievement was calculated. The details are explained below.

4.2.1 One sample T-test for all items in the teachers' questionnaire

A quantitative nonexperimental questionnaire study was used to provide the most in-depth understanding of the perception of STEM project in a selective school from grades 8-11 in the UAE. A series of one sample T-tests were used to answer research questions 1, 2, 3, 4, and 5. Single sample T-test were used to determine statistical significance comparing the means with 3, representing neutrality for research questions 1, 2, 3, 4, and 5. Data were analysed at the 0.05 level of significance. The Statistical Package for the Social Sciences (SPSS) was used for data analysis. Google forms were used to calculate data that was used for analysis. Descriptive statistics were also used to summarise additional insight into questions 1, 2, 3, 4, and 5. Interviews with teachers were conducted after conducting the analysis, to fill the gaps that appeared toward the insignificance in achievement, motivation and differentiation perceptions. Answers were collected and identified then recorded for frequency. The results from the questionnaire revealed that there is no significant difference for the overall (all the items together) construct with t = 1.295, which indicates that the difference was not statistically significant as the t value was less than the tabulated t value t (96) = 1.99. The probability value for this domain was 0.200, which is more than α=0.05, confirming that there is no significant difference. The mean was 3.087 with a standard deviation of 0.546, as shown in table 13 below.

Category	**Mean**	**SD**	**t-value**	**P-value**
Overall construct	3.087	0.546	1.295	0.200

Table 13 One sample T-test of overall construct

4.2.2 Teachers' regressions

Multiple regression was used to explore the effect of three categories, group formation, assessment, and differentiation on achievement, as shown in Table 14 below.

Variables	**Coefficients**	***P*-value**
Constant	-1.297*	0.112
Group formation	0.149	0.181
Assessment	0.446	0.000
Differentiation	0.195	0.078
R	0.554	
R^2	0.307	
Adj. R^2	0.274	

F	9.175	0.000

Table 14 Multiple regression analysis on achievement

Note: *: Unstandardized Coefficient

The coefficient of determination, R^2, shows that 30.7% of the variance in achievement is explained by the three categories. The adjusted R^2 of 0.274 indicates that the R^2 is slightly decreased due to the number of independent variables and the sample size. The F-value of 9.175 is significant ($P < 0.001$) indicating that there is a significant positive impact of the three categories together on achievement. As for the individual contribution of the three categories, the results show that only assessment is significantly and positively related to achievement.

4.2.3 Teachers' questionnaire descriptive statistics

The teachers' perception descriptive statistics by category show that the highest mean is group formation, at 3.49, and the lowest is achievement, at 2.84

Category	Mean	SD
Group	3.49	0.879
achievement	2.84	0.936
Motivation	3.01	0.971
Differentiation	2.98	0.664
Assessment	3.14	0.480

Table 15 Teachers' perception descriptive statistics

4.3 Teachers' interviews analysis

This section has been added to the questionnaire as further evidence was needed to validate quantitative responses. Insignificance appeared in some aspects of the quantitative study, hence, this section was required to fill these gaps and to obtain a better understanding about teachers' perceptions. A mixed-method is used in this study to explore the perceptions of students and teachers toward the implementation of STEM projects in their school. Interviews were conducted with some teachers who teach different subjects, then, a thematic analysis was conducted to analyse the responses of teachers. A summary of the questions and answers is summarised below.

Question 1: What are the preferable techniques to implement STEM in your classrooms?

All engineering teachers' answers focus on the need for professional development sessions for teachers to enhance their abilities, which agreed with Lewis, Capraro and Capraro (2013). Teachers claimed that the projects are not clear and they do not know what is exactly expected from them.

Physics, computer science and math teachers all agree that the best way to teach STEM is to split the project into parts, and relate each part with the topic they are teaching and with real-life scenarios. Furthermore, they believe that combining all parts together gives a complete picture of interdisciplinary projects.

Language teachers believe that their part is as a facilitator to other topics; they take responsibility for explaining the new terminologies, and asking students to use the words in new topics, writing articles as needed about the topics of the STEM.

Question 2: What suggestions do you have to increase students' motivation/ achievement toward STEM?

Motivation: all teachers recommend that announcing competitions about the best STEM project will enhance students' motivation, as well as announcing the best project in the morning assembly and having an honours list to present the best students work will have great impact on students' achievement. Some teachers argue that motivating students toward STEM gives chances to students to be more creative, and gives unexpectedly high quality projects.

According to achievement, all teachers agree that STEM project enhance students' achievements and all perceive the importance of including STEM projects topics in the curriculum. However, the teachers were divided into two groups: mathematics and science on one hand, and computer science, engineering and languages on the other hand. The science and mathematics teachers claim that STEM project topics are related to the curriculum, hence, teachers take the chance to connect the topic they are teaching with STEM projects, which is connected to real-life and other subjects. They also secure benefit from the model of the project by using it in the classrooms, which was mentioned also during the student interviews. The respondents noted that they were happy seeing their projects being used in classrooms to explain lessons. On the other hand, computer science, engineering and languages teachers claim that STEM projects topics are unrelated to the curriculum they are teaching. However, they are presented with two options, the first to find time during their subject pacing to teach the part required in their subject, but they will be responsible for any delay in the pacing. Or they will invest the minimum amount of effort about the project, and hence, accept any work delivered from the students. This group of teachers highly recommend changing the STEM project topics to better fit their curriculums, or to edit the curriculum to adapt it to the STEM project topics. Such teachers believe that if this happens, student achievements will be enhanced.

Summary: motivation

1- Competitions and morning assembly certificates, honours list
2- Presenting in classes
3- Connecting to real-life

Summary: achievement

1- Connecting with the curriculum
2- Using them during lessons

Question 3: What practices should teachers, or the system (due to the centralised curriculum) implement in order to give more chances to enhance student differentiation?

For differentiation, teachers' perceptions include three main ideas, first: STEM projects must be divided into tasks based on student abilities, and each student must find the type of task that suits his/her ability. Second, the main idea about teachers' perceptions regarding differentiation demonstrates that there is a need for diagnostic tests, to identify the level and capabilities of the students before assigning a topic to them; this is to make sure that the topic fits students' abilities and contains required challenges. Some students are less motivated and depend on other students to do their work for them, which could be a result of inappropriate tasks are given to such students. However, if before the project is assigned the teacher effectively diagnoses the level of each student, a suitable task will be given to them and more success achieved. The third main idea introduced by some teachers was that more challenging projects should be introduced; the reason being that high achievers need to be assigned challenges that satisfy their abilities through the STEM project.

Summary:

1- Split projects into parts based on the students' abilities
2- More challenging projects to ensure high achiever engagement
3- Diagnostic tests to identify the level of students to decide what task to assign

Question 4: What suggestions do you have to make implementing STEM better?

Suggestions to secure better implementation include:

From question 1, most teachers suggested PD sessions to be given to them, to explain exactly what they have to do, what is expected from them and what is expected from students. Furthermore, teachers should be instructed on the importance of STEM and why the school system is implementing STEM projects.

The second main common suggestion is time, with teachers recommending that students should have more time for planning, dividing the tasks, communication, and for discussing any difficulties and how to overcome them. They need time also to discuss with other groups to share experience and take advantage of learning from their mistakes. They also need time to meet with their teachers to ask and discuss. Some teachers suggest that STEM must be included in the timetable, or a specific time each week should be assigned for school STEM meetings for all students and teachers. This also had more significance for female students, because male students are more able to meet outside school comparing with female students in the UAE's social and cultural environment. If students have a specific time in school to work on their STEM projects, the outcome will be improved. Another teacher suggestion was for school clubs, which can contain all STEM branches, and students engaged with STEM projects can be directed to the specific clubs that they are interested in. By setting time for club meetings, students can find time to complete their tasks and contributions to their group's success.

The third problematic area suggested by some disciplines was that they do not have a STEM project section in their curriculum documents. This means that they are teaching one topic and the STEM project sits in another topic, coordination between the STEM committee and the curriculum developer in all STEM subjects, should give either STEM projects which contain all curricula that are in progress in the current term, or some changes in the curriculum documents should be made to include the STEM topic.

The fourth main suggestion was to arrange STEM competitions for the best project, which would increase student motivation toward STEM, increase creativity, and also increase their achievement in the STEM subjects. In turn, this would likely increase student attitudes toward selecting STEM subjects in their future studies and careers.

The fifth main suggestion was for teacher meetings to cooperate and coordinate on how to make implementing STEM projects more successful. Each teacher would be able to better understand requirements from each discipline. The school already has class subject teachers' meetings, which could easily be adapted to also talk about STEM projects.

Question 5: Why is STEM important?

The teachers' answers varied for this question. Some teachers think STEM is important because it is an integrated project, provides the chance for students to work on one project with many disciplines, to improve one skill. Furthermore, teachers find STEM important because it is connected to real-life, it makes learning more meaningful and provides chances for students to work on one project that connects all subjects together in a real-life context. It is also perceived as a mixture of real-life context with theoretical information, which gives students opportunities for innovation, creativity and prediction.

Some teachers find STEM projects important because they show students the importance of education, of science and of learning new things. Furthermore, it is perceived as important as it gives students opportunities to improve their skills in many fields.

Some teachers also see STEM as important because 21st century education has changed toward a multidisciplinary framework, which is also part of the vision of the country which makes it important.

4.4 Students' Interview Analysis

This part has been added to the questionnaire as further evidence was needed to validate quantitative responses. Insignificance was identified in some aspects of the quantitative study, hence, this stage was required to fill these gaps and to obtain a better understanding of the students' perceptions. A mixed-method was used in this study to explore the perceptions of students and teachers toward the implementation of STEM projects in their school. Interviews were conducted with some students selected randomly from different classes and grade levels, then, a thematic analysis was conducted to analyse the responses of students. A summary of questions and answers is provided below.

Question 1: What is the most interesting part about STEM projects? What is the least interesting part?

The most positive experience reported by students about STEM projects is the group work, wherein it seems students love to work together and socialise together over one common interest. Some students find STEM to be a chance to have more and closer friends. They enjoy the experience to plan, purchase or acquire materials and to build a project together.

The main challenge for students was how they will meet, school timing is long, and they have many exams during the week days, they do not have a suitable time to meet. Furthermore, some students live far from other group members, making it hard for them to meet to work together. Some students see the project as being difficult, and the load often falls on some students more than others. In addition, some students find it difficult to find the correct place to buy the required material.

Question 2: How does undertaking STEM projects affect your marks? Please explain?

Most students see STEM project having a positive effect toward their achievements. For instance, they benefit from skills, such as searching for the knowledge they need to complete STEM tasks.

Students see that they achieve more in their learning as the STEM projects are connected to what they study (especially maths and physics). Sometimes teachers use their projects to explain other topics effectively. When teachers do so, students become satisfied, and they understand additional topics more extensively, because they have engaged directly and actively with these topics. As they come to know more about the real-life applications of what they are studying, students connect the topic to what is going on around them. Consequently, the data reflects how some students are encouraged to pursue careers in engineering as a direct influence of this positive experience.

Question 3: Explain how teachers give you marks for your project?

Students were satisfied with the way teachers assess their projects. They said that the marks they achieve depend on the work they do, and with most subjects they have to submit a presentation explaining the discipline. In some subjects every student has to prepare a specific part of the presentation, then students compile each individual contribution together and submit it to the teacher. The teacher gives every student in the group a different mark depending on their individual work.

Chapter 5: Discussion, Conclusions and Implications

The interdisciplinary STEM project has a significant effect on students' motivation and achievement. It is also a fruitful field for teachers to offer differentiated practices based on student preferences and abilities, which also helps in assessing students based on their individual skills. Furthermore, STEM offers an environment for students to work cooperatively, allowing them to gain more sociocultural and communication skills. A variety of assessment tools can be used to assess STEM projects, which is also suitable for different students' abilities.

This chapter presents the discussions, conclusion, recommendations, suggestions for further studies and limitations of the study.

5.1 Discussion

This is study is set out at the end of term 2 in a selective school in the UAE for students from grades 8-11 after implementing STEM projects in both term 1 and term 2. The main purpose of the present study was to investigate the perceptions of teachers and students about the implementation of STEM projects from five perspectives: group formation, achievement, motivation, differentiation and assessment. Moreover, this study aimed to identify and understand any difference in the five previous perspectives between male and female students. The study, as described in chapter four, was divided into two stages: quantitative and qualitative stages. The findings of this study showed coherence between the current research and the previous studies. However, based on the feedback obtained during the interviews, some recommendations about increasing the motivation, achievement and differentiation practices were collected from both teachers and students. Han (2014) claimed that student achievement significantly increases if the learning environment is STEM PBL. This showed coherence with the current study's results.

In the following sections, a discussion of the group questions is divided into four parts: effects of group formation, effects of STEM projects on achievement and motivation, effects of STEM on differentiation and assessment and a discussion of some regressions measured from the quantitative results.

5.1.1 Effect of group formation

When students work in groups, they are afforded more chances to develop a variety of skills and abilities, such as critical thinking, intrapersonal and interpersonal intelligence, collecting and analysing data and communication skills. Furthemore, accepting other people's ideas, being an effective team member and getting a chance to be a team leader, as wella as problem-solving techniques are all made available. Combined, this will improve the educational outcome (Sofroniou and Poutos 2016).

Kyprianidou (2012) argued that heterogonous group formation increased student productivity in the groups, and students became more aware about themselves and other group members, allowing them to gain more sociocultural skills.

The result showed student satisfaction toward STEM PBL. Returning to the main research question of whether group formation affects the learning outcome, and if the group duty distribution enhances students' achievement, students showed their excitement working cooperatively in groups. This indicated the effectiveness of STEM PBL as a student-centred approach, which increased their motivation toward STEM subjects.

Navarro et al. (2012) argued that the process of dividing students into groups, plays an important role in the success of cooperative learning. Students in the current study preferred to work in a heterogeneous group, which is also built based on friendship. Above average students complained that below average students depended on them finishing all the tasks, which teachers noticed and subsequently distributed tasks based on students' abilities. Geographical areas also played an important role, because students were more likely to meet after school hours to work on their projects if they lived closer to their group members. On the other hand, teachers also preferred heterogeneous groups regardless of the geographical factor, which must be taken into consideration. With regards to gender differences, no significant differences were found between males and females in relation to group formation.

Students considered the most interesting part in STEM PBL to be working in groups. Students admire working in cooperative student-centred groups, where they develop their communication skills, taking decisions, carrying responsibilities and gaining presentation skills.

5.1.2 Effects of STEM projects on achievements and motivation

Based on the results of several past studies about the significant difference between students who use STEM PBL and students who study the same material at the same time using traditional teaching methods, it can be observed that PBL provides more self-capability toward learning STEM disciplines and student results improved compared to the normal teaching method (Bilgin, Karakuyu and Ay 2015). Moreover, Nelson et al. (2011) argued that the averages of students who graduate from STEM schools are higher achievers than the averages of students who graduate from non-STEM schools.

The most interesting part in this study is the positive attitude toward STEM projects from both teachers and students. All agree on the positive effects of STEM on motivation and achievement. Students were satisfied with the cooperative environment.

Lewis, Capraro and Capraro (2013) argued that in order for students to reach higher achievement, teachers have to intervene more in student practices in the first years of implementation. In addition, teachers need to attend more PD sessions about implementing the best techniques in teaching STEM PBL. This agrees with the teachers' suggestions about having more information about STEM projects, their objectives and how to implement them.

Han (2015) recommended that a key motivation of STEM projects, which is the group work that has effects on students' attitudes and behaviours, students cooperatively work in groups discussing taking decisions, which helps them to reach social maturity. The current study's third question was to find the effect of STEM on students' motivation toward STEM. Quantitative and qualitative results showed a positive effect of STEM projects for male and female students. Students consider STEM projects as ideal environments where they can work without stress, in collaboration with their colleagues, searching for solutions, and in which they feel themselves real engineers working to find solutions to real-life problems. Tseng et al. (2013) recommended the implementation of STEM projects as a major factor to increase students' motivation to study, and to select STEM careers in the future after they graduate. Male students considered STEM projects more motivating than female students. A positive significance was found between the male and female students' answers. this is in agreement with the recent study of Gnilka and Novakovic (2017) who argued that female students still have less susceptibility to choose STEM careers. To remove the barriers around STEM careers for female students an intervention must be prepared to improve their perceptions and confidence in STEM careers. In addition to school counsellors must take the responsibility to reduce the barriers for females according STEM careers, teachers, parents and community must also take an active role in this area.

According to teachers' perceptions about the effect of STEM on students' motivation to study, a positive significance was measured in the questionnaire, which also corresponds to the literature. The teachers suggested competitions to be enrolled in the school covering STEM projects and certificate distribution in the morning assembly was perceived as a means to increase motivation to students to work harder in STEM projects, which can affect the students' achievement positively. Maths and science teachers suggested presenting STEM projects in their classes, so students will be proud of themselves and encouraged to invest their energies to achieve positive results.

5.1.3 Effects on differentiation and assessment

Many factors may affect differentiation, which is providing suitable activity to each student based on their skills and abilities (Bilgin, Karakuyu and Ay 2015). Other than the cognitive level of each student and their different abilities, the school environment, parents, the broader community and the content are all factors that must be taken into consideration in designing STEM differentiated interdisciplinary projects (Capraro et al. 2016).

The fourth and fifth questions in this study were designed to investigate the process of differentiation, how teachers get benefit from the nature of STEM projects to distribute tasks taking differentiation into consideration, and how the difference in students' abilities influences STEM projects. Furthermore, these questions were designed to identify the assessment practices that teachers use during the implementation of STEM projects, and the degree to which students are satisfied with these practices.

Student perceptions about how STEM projects have a range of tasks distributed among them based on their abilities was significantly positive. Students were satisfied with the task assigned to them. They consider a chance to work the part they are good at. Female students showed less satisfaction about how STEM projects give differentiated tasks. To the contrary, the teachers' questionnaire showed less agreement toward the effectiveness of STEM projects to provide differentiated tasks.

Han et al. (2015) argued that it is not possible to guarantee a perfect method to address each student's diverse learning strengths and needs and create opportunities for students to demonstrate their learning in different ways. Variations in teaching and learning activities must be used to develop learner skills, and activities must involve whole group, small group and individual students. Creating this diversity in classrooms increases the level of motivation and achievement for students, and other factors affecting the achievement levels include the teacher's expectations from students. This provides inadequate information about the teachers' beliefs. The interviews showed a lack of teachers' experience in implementing STEM projects as being the reason for this difference. The importance of PD sessions to train teachers to use more techniques to address each individual student in teaching STEM projects was also evident.

5.1.4 Regressions

Multiple regression is used to explore the effects of three categories: group formation, assessment, and differentiation on achievement. The results showed all categories positively affect achievement. Guyotte et al. (2015) argued that effective group formation enhanced students' achievement. On the other hand, Han, Capraro and Capraro (2015) argued that STEM PBL affects different students differently. Bilgin, Karakuyu and Ay (2015) argued that well-designed differentiated practices give better results for different students.

The regression obtained from this study has coherence with similar results. In addition, this study differs from past studies inasmuch as it measured the effect of three factors on motivation that have a positive effect on achievement.

5.2 Conclusions

The second question asked if STEM projects affect students' achievements. Han et al. (2015) argued that STEM PBL affects students' achievements based on the student's skills and capabilities. The students' questionnaire in this study showed that if students harboured a low level of trust in STEM projects it affected their achievements negatively. However, during the interviews, students showed high motivation toward STEM and explained how STEM affected their marks positively; first noting how easy and interesting STEM projects are and getting marks for their work, and second noting how STEM projects are related with the topic they are studying, especially in mathematics and physics. In these subjects, students enjoy the benefits of understanding the topic and connecting it to real-life, as well as to the hands on activity involved. Teachers of applied engineering and computer science complained that the topics of STEM projects are largely unrelated to the topics they are teaching in the curriculum. Teachers suggested professional development sessions which can facilitate their role in implementing STEM projects should be held. Capraro et al. (2012) recommended the students experience during STEM, which reflects on their motivation and achievement, depends on how well teachers understand STEM and how professional they are in implementing it.

Comparing male and female students in achievement, male students had a more positive attitude toward the positive effects of STEM on their achievements.

5.3 Limitations

This study was conducted in one selective school that implements STEM PBL. It could be considered a limitation of this study that the research only measured the perception in one school, while this selective school has other branches in other emirates in the UUAE.

The sample of this study is N = 187 male students, and N = 134 female students, the larger the sample the higher the data accuracy in the qualitative results would be.

Another limitation of this study is the validity of some questions in the questionnaire, specifically in the group formation and differentiation sections, where two items were deleted to validate the questionnaire items.

5.4 Recommendations

The recommendations after this study can be categorised in five sections, as follows.

5.4.1 Recommendations for group formation

Raiyn and Tilchin (2016) argued that self-formation groups by students can give better results in the assessment when the group finishes the required task as a result of accountability sharing where all students feel responsible for the group result. Furthermore, this could encourage students to pursue higher order thinking because each group member is accountable for the final score.

The group formation method followed in this school is heterogeneous grouping, which the literature suggests should be used for below average students. However, above average students prefer the homogenous group design. Teachers should take into consideration the nature of students and their preferences. The results showed students prefer to work in groups based on friendship and geographical area, as it is difficult for them to meet after school where most of their work is done after school.

5.4.2 Recommendations on achievements and motivation

The recommendation in this field can be summarised by connecting the STEM project with the curriculum being taught to raise the level of achievement. Teachers suggested ways to increase students' motivation toward STEM by announcing competitions for the best project and distributing certificates for the winners. In addition, displaying projects in classes is expected to increase student motivation.

Han et al. (2015) suggested that creating diversity in the instructional method in introducing STEM enhances the motivation of students to learn. On the other hand Lewis, Capraro and Capraro (2013) recommended increasing the difficulty of ill-structured tasks to give more motivation.

5.4.3 Recommendations on differentiation and assessment

From the results of the interviews, this study found that teachers in this school assess the STEM projects at their final stage based on the final model and the presentation, which includes the stages of the STEM project. According to the interviews, most students tend to work on the project just before the deadline, if teachers assessed the project phase by phase, this will guarantee a formative assessment, and an appropriate time distribution of the project which reduces the pressure on students, increases motivation to study and gives better results (Yoon 2009).

5.4.4 Recommendations for gender differences

Zaidi and Afari (2016) argued that there is a huge gap in the UAE between males and females with regards to their perception of STEM subjects, especially math and science. Even though the UAE is an oil-dependent country, this industry is considered to be the first, in addition to the need for engineers from both genders, to run the renewable energy projects and some projects like nuclear projects and space projects. Therefore, there is a huge need for qualified engineers to fill these sectors. The UAE is trying to encourage both males and females to engage with the STEM discipline and fill the country's need for qualified STEM professionals.

This study showed similar results with previous research, by making recommendations to increase the motivation of female students to engage with STEM projects, by facilitating their work by providing them with the required materials. This factor was one of the most difficult areas to improve as mentioned by students.

5.4.5 General recommendations

In general, professional development sessions are needed for teachers to provide clear guidance on STEM and about what is expected from teachers in its implementation. This is indicated by the research to have a positive influence on the achievement of students.

Another recommendation is connecting current STEM projects with the curriculum documents.

Another important recommendation is assigning time to teach STEM within the school hours. In this school, teachers introduce the project to students and then students work on the project after school hours, which causes difficulties in group meetings, especially for female students. If the school offers weekly periods where students can collaborate it will have a positive result on the students' levels of achievement.

The last recommendation is the time frame, wherein time should be clearly divided throughout the term. Students are surprised when their teachers suddenly ask them to submit the project. This is also connected to the assessment which should be formative.

5.5 Directions for Future Studies

This study objective was to investigate the perception of STEM PBL experiments in a selective school focussing on specific perspectives. The most important reason to implement STEM projects is increasing students' achievement and increasing their motivation to select STEM careers once they have graduated. In this study the perception of students and teachers toward achievement was measured, but the study did not measure the change of achievement; a future study is recommended to compare the achievement of students in STEM schools and non-STEM schools. Another suggestion is to conduct a study to compare student achievements before and after implementing STEM projects.

Another finding of this study is the significant difference between males and females in achievement and motivation toward STEM projects, but this study did not intend to explain the reasons behind this. Considerably, more studies must be done about the reason of the significant difference between male and female students toward STEM PBL, and how to reduce it.

Furthermore, a study should be conducted that takes into consideration the number of students who attend STEM majors at university after high school, and a comparison between STEM and non-STEM schools to measure the effectiveness of how STEM affects student attitudes toward STEM careers.

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