Investigate stakeholders' perceptions of best practices of STEM education in the United Arab Emirates

التحقيق من تصورات أصحاب المصلحة حول أفضل ممارسات التعليم التكاملي للعلوم والتكنولوجيا والهندسة والرياضيات في الإمارات العربية المتحدة

by

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Abstract

The United Arab Emirates (UAE) is in the transition from an oil-based to a knowledge-based economy. This shift requires a workforce that can develop 21st-Century Science, Technology, Engineering and Mathematics (STEM) skills. In order to make this transition and integrate with the global economy, the UAE must enhance the workforce channels concerned with STEM education to prepare current and future workforces. Schools in the UAE ought to prepare and motivate the students to join STEM careers. This study investigates stakeholder perceptions regarding STEM best practice in the UAE towards developing a STEM model. The data from this study in the UAE revealed that STEM practices are not common and require significant instruction for implementation. The recommendations of this study form a basis for establishing an effective STEM model in the UAE.

Keywords

STEM-PBL-MEA-CTE-ABET-PISA

المُلخص

إن دولة الإمارات العربية المتحدة في طور الانتقال من عصر النفط الي عصر الصناعة المبنية على المعرفة. تلك النقلة تستوجب جيل جديد من العمالة البارعين في مهارات التواصل للقرن الوحد والعشرين ومهارات العلوم المتكاملة ستيم (العلوم، التكنولوجيا، الهندسة والرياضيات). من خلال ذلك الفكر لأجل الانتقال إلى الاقتصاد القائم على المعرفة نظيراً للاقتصاد العالمي، يجب على دولة الإمارات تعزيز قناة القوى العاملة فيما يتعلق بتعليم العلوم والتكنولوجيا والهندسة والرياضيات. يجب على المدارس في الإمارات إعداد وتحفيز الطلاب للانضمام إلى حقول العلوم والتكنولوجيا والهندسة والرياضيات. نتيجة لذلك، تبحث هذه الدراسة في مفاهيم وتصورات أصحاب المصلحة فيما يتعلق بأفضل ممارسات للعلوم التكاملية في دولة الإمارات العربية المتحدة. وتسلط الدراسة الضوء على تصورات أصحاب المصلحة وأفضل ممارسات ستيم وأخيراً اقتراح نموذج ستيم في دولة الإمارات العربية المتحدة. أظهرت نتائج المعطيات من هذه الدراسة أن ممارسات ستيم ليست شائعة في دولة الإمارات العربية المتحدة وتتطلب تعليمات واضحة لاستراتيجية تنفيذ ممارسات ستيم في التعليم من قبل صانعي القرار ومنظمات الطاقة والصناعة في الدولة بالتعاون مع المؤسسات التعليمية. التوصية التي نتجت عن هذه الدراسة هي الأساس لإنشاء نموذج ستيم تتبعهُ المؤسسات التعليمية في دولة الإمارات العربية المتحدة.

الكلمات الرئيسة:

العلوم التكاملية ستيم-التعلم القائم على المشاريع- التعليم المهني التقني- نشاط الاستنباط والنموذج- مجلس الاعتماد للهندسة والتكنولوجيا- برنامج تقييم الطلاب الدوليين

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CHAPTER ONE

INTRODUCTION

The United Arab Emirates (UAE) is reforming its education system to develop national capabilities and competencies to accommodate the rapidly evolving global economy. This dissertation study will analyze the best international practices of STEM and examine domestic stakeholder perceptions regarding STEM education in the UAE. Additionally, this paper also examines the suitability of the STEM education model for K-12 in the UAE and the demographic variables influencing stakeholders. The findings are intended to foster a greater understanding of STEM stakeholders' perceptions regarding STEM education in UAE and ascertain whether there is an appropriate and feasible STEM model for K-12 based on the research findings.

Encouraging UAE citizens to be productive is a keynote process that ought to be constructively implemented from the years of early education to higher education. Productivity is strongly correlated to a transfer of theoretical knowledge to tangible, valuable and useful products for the community. To promote productivity, educators need to focus on Project Based Learning (PBL) that teaches students how to link the knowledge of various disciplines and benefit from that knowledge by finding scientific solutions to problems. Linking knowledge and the integration between Science, Technology, Engineering is STEM education. An isolated knowledge of any STEM discipline is not sufficient to nurture the students to be productive. On the other, hand, educating them to integrate the knowledge and skills by PBL is the main focus for production of creative solutions for real-life. It has been asserted that "Equally important, in 2014 the National Assessment of Educational Progress introduced the Technology and Engineering Literacy assessment, designed to measure the extent to which 4th, 8th, and 12th grade students were able to apply technology and engineering skills to real-life situations" (Phelps, Camburn and Min, 2018). Hence, the interdisciplinary nature of STEM skills ought to be the target for achieving the applied education and productivity for solutions to real-life problems.

The traditional methods of teaching and learning are not effective ways to teach students to be productive. Productivity requires the knowledge and the skills to apply the knowledge. For students to grasp the skills of productivity, they require specialized skills for investigating problems, conducting exploration to understand the problems and finding appropriate solutions for those problems. However, the students require skills to represent and demonstrate the problems, resources for finding scientific solutions, tools and skills to apply the suggested solutions considering the scientific methods, STEM education and Project Based Learning (PBL). In United Arab Emirates (UAE) the educational national agenda appeals for the development and reforms in the educational sector to fulfil the 21st-century skills and the demands of future generations careers and UAE economic destiny. The UAE is undergoing a transformation stage from a primary resource, oil-based economy to the one that features all the hallmarks of the Information age; an era of innovation that promotes and encourages features of this new economy, and aspects of production and trading. Such a transition demands the preparation of a generation of citizens to adapt and to acquire compatible skills for the UAE's economic future and the anticipated jobs and careers in the region. As the education sectors in the country are preparing the future youth to be the next generation of drivers of the economic steering gear, it is critical to adapt the curricula to nurture talent and fulfil prerequisites for 21st-century jobs.

An integral part of STEM education is vocational education, and the various economic sectors in the UAE represent opportunities for educational reforms initiatives. This new era will present opportunities to promote students' higher order thinking, research methods and expose them to the community real-life problems and increase the understanding of the labor market and the need for productivity. Vocational education involves the preparation of apprenticeships and mastering skills such as research skills and teamwork that enhance socialization. In turn, this helps students grasp the tacit skills that are necessary to their careers from the aspect of building relationships, collaborating and cooperating to be fruitful in their team and field (Bancroft, Benson and Johnson-Whitt, 2016).

Clear instructions are required to be followed by Education stakeholders to implement effective and successful STEM education outcomes, to achieve these reforms and develop the educational sector, for their learners. Education policies in the UAE are issued by several entities such as the Ministry of Education (MOE), the Knowledge and Human Development Authority (KHDA) in Dubai, and the Abu Dhabi Education Council (ADEC). MOE, KHDA and ADEC tasks are to ensure that K-12 education outcomes in the UAE schools are aligned and linked to the global best practices and coordinating with the post-secondary education sector to develop the educational systems and prepare for futures workforce (Gonzalez, 2008). The UAE Education Councils aim to encourage students to engage in innovative and creative activities that require STEM-related knowledge. Robotics and Artificial Intelligence, for example, require interdisciplinary STEM skills and knowledge to design and develop innovative solutions for real-life contexts. Several competitions and awards like the First Lego League (FLL) and the World Robot Olympiad (WRO) have been launched in the UAE to encourage students to participate in world-class technology education challenges (Afari and Khine, 2017).

Reforms in Education to promote the STEM syllabi will transform and enrich STEM literacy, and student skills will consequently expand the pipeline of students entering STEM fields in postsecondary education. Moreover, embedding and scheduling STEM in educational instruction increase student engagement in authentic learning processes, exposing them to real-life applications to investigate, explore and learn. Involving economic sectors with STEM Partnerships, such as Energy authorities and the other Industrial sectors in the UAE, can foster collaboration between them and educators that focus on establishing and weaving authentic learning processes into STEM education curriculum and instruction. Thus, students are exposed to real-world problems and think critically, creatively and innovatively to activate their knowledge and produce solutions instead of just learning to take tests (Israel, Maynard and Williamson, 2013). It has been found that the results of primary meta-analysis expose that interdisciplinary STEM instructional education among subjects have positive impacts on student engagement, learning and critical thinking, however, the approaches to implementing integrated STEM disciplines still have barriers (Becker and Kyungsuk, 2011).

1.0 Research Problem

The UAE has the intention to reform the Education sector to prepare its citizens for a diverse economy, discover alternative resources and new products and production techniques rather than depending on the finite oil and gas resources. These plans and preparations require investments in the literacy of innovation for economic growth and to build the knowledge-based economy for the education infrastructure. As an action-plan to transform the UAE future economy, the educational sectors in the UAE have sought to develop processes for preparing the citizens to be an integral part of the UAE economic shift and production operation (Matherly, Amin and Al Nahyan, 2017). As an executive process to start the educational reform strategies, the 2021 UAE National Agenda Education vision asserted raising the quality of education systems in the UAE. This development in education requires a comprehensive shift from the traditional methods of teaching to contemporary educational methods that are compatible with the 21st-century learners and the desired characteristics of the international and the UAE workforce.

Also, UAE policymakers and academics have recognized the need for the transformation in the educational systems to raise the level of UAE students in the Program for International Student Assessment (PISA). PISA is a standardized test designed and generated by the Organization for Economic Co-operation and Development (OECD). The PISA test measures 15 years of a students' performance in mathematics, science and problem-solving. Furthermore, the PISA results and its analysis reveal a students' tendency to pursue their higher education and careers in the science, engineering and technology fields. The results aid in finding the limitations and failures in specific areas of the education system as well as areas for improvement. Thus, the PISA results help a country to direct their students to the required education and professional channels for the future career in the country (PISA 2015 results in focus, 2018). Consequently, PISA results are spotlighting on the room of improvements and development in educational sectors that are necessities to the economic requirements of the country.

The OECD aims to evaluate the countries educational investment to prepare generations that are capable of meeting the demands of future careers. In order to fulfil the capability of an employee to meet the 21st-century career requirements, the education sector needs to undertake reforms and shift from general to vocational education. UAE students have participated in the three rounds of PISA tests that have were held in 2012, 2015 and 2018. The results of the PISA 2015 test revealed that UAE students have weaknesses and are below the OECD average scores in Science, Math and Reading. Moreover, UAE students did not demonstrate expertise in extrapolating from their knowledge they know, applying their knowledge or reproducing from their scientific knowledge. Thus, UAE students' results are below the expectation (OECD Secretary-General, 2015).

Based on these PISA results, the application, extrapolating and application of knowledge are the most significant issues that ought to be grasped by the students. Moreover, the results assert the necessity of STEM education and PBL to promote students' skills in interconnecting and applying knowledge through investigation of real-life problems, designing and engineering of innovative technical solutions. Moreover, the implementation of STEM is tightly correlated to the increase of the UAE students' attainments in PISA since the PISA test focuses on the application of science and math knowledge with relation to the real-life application and problem-solving. UAE students' results in PISA tests 2015 were notably and extremely low compared to counterpart countries, that returned to several reasons as the researchers confirmed it.

In the UAE, the demand for future engineers and employees with STEM skills is crucial to fulfil the economic changes in the region and to keep up with the need of preparing the upcoming Emirati generations for vocational and manufacturing careers. It has been mentioned that "The United Arab Emirates provides a unique context to study this phenomenon as it is a traditional, patriarchal society that is highly dependent on Engineering knowledge and skills, especially within the oil and gas sectors" (Pasha-Zaidi and Afari, 2016). This underscores that the UAE is in a transitional period where the future anticipated careers require employees to master essential STEM skills. The challenging areas of the implementation are to reform the educational sectors to change the teaching and learning methodologies to foster on STEM disciplines development and to fund the STEM resources. The research on approaches to STEM integration has been undertaken, but still, several practical challenges to their application exist. The successful STEM integration approaches require STEM teachers, school leaders and individual administrators and functional characteristics embrace new instructional methods, collaboration, perceptions, implementations and delivery of the new methodologies. The education instructional methods are highly correlated with consistency and sustainable implementation. The harmonious communication between these Education stakeholders will improve, develop and create a consistent, sustainable educational/instructional system.

Although all the Educational Councils in UAE are initiating and encouraging STEM education, various STEM stakeholders recommend intervening to guide the STEM education methodology in education facilities such as primary and secondary schools and tertiary education institutions.

1.1 Background and significance of the study

The significance of STEM education in K-12 school levels is that it will affect positively on student pre-college preparation and their tendency to join STEM fields and master STEM skills as part of their careers. The school college preparation programs, STEM courses offered for the students, PBL and the nature of internship programs offered to the students in High school curricula are all factors that dramatically affect student enrollment at STEM colleges. Student interest in enrolling with STEM colleges indicate that careers based on the anticipation that STEM employees are required for the future STEM jobs. It has been asserted that “Despite the recent policy proclamations urging state and local educators to implement integrated science, technology, engineering, and mathematics (STEM) curricula, relatively little is known about the role and impact of pre-college engineering courses within these initiatives. When combined with appropriate mathematics and science courses, high school engineering and engineering technology (E&ET) courses may have the potential to provide students with pre-college learning experiences that encourage them to pursue STEM college majors.” (Phelps, Camburn and Min, 2018).

STEM and PBL skills are required to develop a students’ vision, their way of thinking and as a result, their career skills. Students educated in school are future citizens who will participate in building their economy. Internationally, STEM education has been given significant attention, that attention since World War II, whereby politicians realized that STEM knowledge is essential to develop war machines for production and subsequently to rebuild the country and produce products to sustain the economy after the war. Consequently, educational reforms have been started, despite that, various countries implemented STEM education differently and in it is own way (Ritz and Fan, 2014).

Despite the tremendous importance of STEM implementation in schools to encourage students to think critically and employ interdisciplinary knowledge, instructions for implementing STEM activities into curricula is neither internationally nor nationally accessible. Consequently, it is a complex field that requires investigation and efforts on the part of education stakeholders to initiate and find effective approaches that will engage participants in STEM education (Assefa and Rorissa, 2013). Research in the United States related to STEM educational reforms asserts that several institutions, government and agencies were involved with STEM education efforts such as activities and resource development. Both agencies and government will need to provide significant investment to implement STEM in education to prepare future generations of 21st-century workforces who should have the readiness and skills to be productive to fill STEM future vacancies based on the vision of the National Science Foundation (NSF) (Assefa and Rorissa, 2013).

1.2 Purpose and questions of the study

The primary purpose of the study is twofold: to investigate stakeholders’ perceptions of best practices of STEM education and to develop further a possible model for implementing STEM education in the UAE. Furthermore, this forms the basis to develop a best practice model of

STEM instruction and the stakeholders' perceptions of its utility in UAE middle and high schools. The research questions are:

- What are the best practices of STEM education as presented in the Literature Review?
- What are the stakeholders' (Students-Educators- STEM partnership (Energy authorities and other Industrial) perceptions regarding STEM education in the UAE?
- What, are suitable or appropriate STEM education Models for K-12 in the UAE?
- What are the key demographic variables influencing stakeholders' views of STEM education?

Corresponding to the preceding study regarding STEM, the research results of these studies proposed that the educators' perceptions about STEM, their personal knowledge, and their understanding of the knowledge are intrinsically linked to the effectiveness of STEM delivery in their classrooms. Furthermore, reciprocal arrangements and networking between STEM educators will support ways to explore and understand their STEM counterparts' subjects and foster cooperation to create interdependent and integrated symbiotic curriculum (Bell, 2015).
Therefore, the intention of this study is present the best practices of STEM education based on international analysis, and to investigate stakeholders' perceptions regarding STEM education in the UAE. An additional aim of this study is to develop further a possible model of STEM education instruction based on analysing documents, survey data and the analysis of STEM stakeholder perceptions.

1.3 The context of the study

This study was conducted at an American curriculum school in the UAE, which is committed to providing high-quality STEM education to UAE youth. This study was conducted for STEM stakeholders' in the UAE to investigate their perception regarding STEM education.

All participants were STEM stakeholders living in the UAE, and they were either working or studying in a relevant STEM sector. 88 students from middle and high school responded to the first survey to obtain their perceptions. STEM stakeholders such as teachers, Head of STEM departments and STEM Partnership members from Energy authorities and the Industrial sector in the UAE participated in the second survey to elaborate on their perceptions and utilization of STEM education instruction effectiveness for the learners and the future workforce.

1.4 Structure of the dissertation

Chapter one presented in this section highlighted the importance of the topic and related the significance of the study to previous research. It also explains the importance of STEM education to the UAE and presented the questions that drive this research. Chapter two discusses the theoretical framework behind the STEM education and their history, significant for preparing the future workforce and the effectiveness of STEM education stakeholders' perception on the implementation STE education process. Chapter three explains the methodology used to conduct this study and provides details on the samples and instruments to analyze the data. Following is chapter four, that demonstrates the results of the study. Finally, chapter five which discusses the data draws the conclusion and presents the recommendations and the limitation of the study.

CHAPTER TWO

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The aim of this chapter is to provide an overview of the best practices of international STEM education as an analysis. This chapter consists of two sections: the theoretical framework of the study and the literature review relevant to international STEM best practices including stakeholders' perceptions pertaining to STEM education instructions and implementation. The literature review contains three parts: International STEM Best practices, STEM Stakeholders' perceptions and Demographic Influences.

1.1 The Theoretical framework of the study

The human development centric on personality, socio-emotional and cognitive developments. There are two main theories of cognitive developments which attain consent, those are the theories of Jean Piaget and Lev Vygotsky. STEM education encourages shares ideas of the constructivist and collaborative learning theme intrinsic to Piaget's theory. In addition, STEM education exposes students to real-life applications and cooperative learning that are central themes to Vygotsky's Zone of Proximal Development (ZPD) (Bishop 2013). Furthermore, the human development theories and integration will be used as bases of the STEM and PBL education modes and reveal their importance to student development.

Piaget's theory states that human development and abilities are changed over time by active interaction with the environment. In each stage of the life-cycle there are requirements and circumstances to encourage development based on the characteristics at any given human age. The developments involve a scheme which are the objects in the environment around the human and the adaptation and assimilation of these scheme objects appropriate for the interaction and understanding based on the participant's age stage (Slavin 2014). Piagetian theory affirmed that students build knowledge by using five reflective abstractions (interiorization, coordination, encapsulation, generalization and reversal). The STEM education and PBL models similarly promote the five reflective abstraction and expose the students to real-life application, working collaboratively, communication, as well as preparation for future careers and workforce challenges (Zollman, 2012).

Vygotsky describes learning as a social process and the promotion of human intelligence in culture. Vygotsky believes that social interaction and cooperation plays a significant role in human development and cognition and learning is learned at two levels, the

first level is the interaction and how this is integrated into the individuals' mentality. The second level is the Zone of Proximal Development (ZPD) which indicates that each person has their own exploration zone which can be developed by social interaction. To promote a ZPD in classrooms, teachers use scaffolding to support learners to understand and develop their skills. Scaffolding includes collaborative learning, discourse and modelling (Arshavskaya, 2018). Based on Vygotsky theory and especially the ZPD, students must learn through STEM PBL education since it is integrated into ways at various school stages and exposes students to practical areas of STEM disciplines. STEM PBL focuses on students to be able to interpret and construct knowledge by experience and intellectual understanding of knowledge whether by students themselves or by cooperation with other students, educators or experts. The interpretation and cooperation with experts are the ZPD concept of Vygotsky (Bell, 2016).
Thus, the students will be confident in joining STEM faculties in the postsecondary stage. Referring to the ZPD diagram (Figure 1), for the learners to be exposed for further knowledge and new experiences, support and help must be provided to widen and develop the learner zone and skills. Equivalently, for the students to be prepared for the workforce and knowledge-based

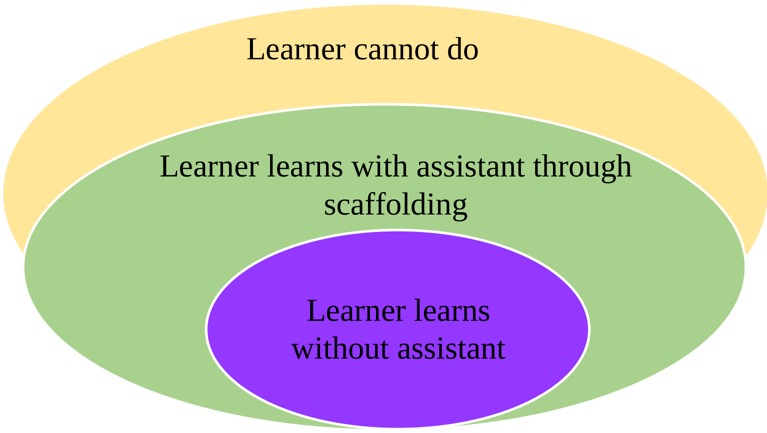

Figure 1: Vygotskian Zone of proximal Development

economy, the preparation must start form school stages by expanding their skills in STEM disciplines.

According to Han, Capraro and Capraro (2015, p. 1093) "STEM PBL is grounded in the theoretical background of constructivism where students are engaged in the diverse components of problem-solving, interdisciplinary curriculum, open-ended questions, hands-on activities, group work, and interactive group activities".

Drake and Burns (2004) defined the PBL as a Transdisciplinary Approach which allows the students to pursue learning without restriction by a subject and in a holistic way. The PBL allow the students to expand the students research-based learning, asking open-ended questions, retrieve of pre-knowledge and correlate the pre-knowledge with the explored knowledge to apply themselves to solve a real-life problem.

Theory	**Description**	**Relation with STEM education and PBL**
Piaget	Students cognition developed in each age cycle by collaboration with peer, discourse, interpret and build knowledge from interaction with the objects in Scheme, adaptation and assimilation of those objects.	STEM and PBL allow the students to be exposed to real-life scenarios and interact with new objects in the scheme where the cognitive abilities will be developed.
Vygotsky	The ZPD concept is that the knowledge the students cannot learn by themselves; can be learned by collaboration with experts or educators.	STEM and PBL promote the exploration, research-based, collaborate and modelling which expose the student to career skills.
Susen	Approaches for curriculum integration.	PBL is a Transdisciplinary Approach to achieve the integration between disciplines of STEM.
Capraro	Interdisciplinary approach STEM PBL as constructivism method.	STEM PBL promote 21st-century skills.

STEM education has significant potential in educational reforms worldwide. Yet the instruction for implementing the STEM education has potential challenges when designing the school programs and curriculum and still instructional practices and recommendations for the developments are ambiguous or the initiatives for the development of STEM education are often overlooked and not systematically developed (Bybee, 2013).

Enormous definitions of multidisciplinary STEM teaching and learning have been issued. A variety of statements defining STEM education revolved around correlate between more than one STEM subjects in the education process. It has been defined that STEM education is the explored approaches in the process of teaching and learning between two or more STEM disciplines in the learning institution. Additionally, STEM education ought to connect it is disciplined that entails the real-life problems and contemporary controversial issues. Moreover, it requires educators solicit to integrate engineering design skills and technologies while teaching the pupils to produce a product as a solution for the real-life problem. The rational purpose for the integration between the STEM disciplines is to improve the students learning within an authentic meaningful application (Shernoff et al., 2017). The necessity of developing the authentic education methodologies and content in K-12 school cycles is to build relevant standards and subjects to the marketplace, community and to prepare the students to college-readiness level. Building vibrant connections between the STEM subjects by perceiving the authentic real-life and international issues will produce responsible learners culturally and pedagogically and will increase the STEM talent pipelines and skilled workforce for the future economics. The economics sophistication is the key area of focus and needs sustained and a strong education system that will prepare the skilled workforce (Johnson, 2012).

There are widespread depictions that the reforms and developments in the educational systems to implement the instructional STEM education will yield in the next generation of students to elicit from the STEM knowledge to solve controversial international issues. However, significant challenges are still disrupting the educators form achieving the elusive STEM education. The designers of the multidisciplinary STEM strive to develop a correlation between the disciplines avoiding the dilution of the skills of each discipline, consequently thus connectedness require extrapolating of additional, overblown instructions alongside the current curriculum. Although designing of the integrated curriculum will offer the students the opportunities for open-ended, PBL and PBL in an experiential learning environment. The experiential learning environment possesses the characteristics of higher-order thinking for the learners, learner-centered classrooms, learner reflection on their work, teamwork, metacognitive coaching in a multidisciplinary STEM classroom (Baker and Galanti, 2017).

Furthermore, the PBL in the multidisciplinary STEM classrooms fosters and boosts learning by including education that contains the critical vision for the tendency of integrating making with obvious considerations of pedagogical inquiry-based learning (IBL) practices. The STEM and PBL encouraging the scaffolding skills for the students by participating in teamwork and expressing verbally, visually, engineering the designing and transforming the knowledge and the visualization into the 3-Dimensional models to demonstrate the solution of the real-life problem (Smith, 2018).

It has been mentioned that the STEM-educated workforce is deemed necessary for the development of the growth of economics and that the STEM skills are immensely significant for the development of the products in the labour markets (Boyd and Tian, 2016). Consequently, promoting the productivity culture in education is highly critical and plausible to prepare the future workforce. Embedding the making skills through STEM education are endeavours that encourage the productivity and producing of solutions by implementing the engineering skills and technology tools in the maker-space labs (Marshall and Harron, 2018. Thus, there is an emphasis on STEM education, so the students can gain a robust understanding of the connectedness of STEM disciplines and expand the scope of students entering STEM fields (Israel, Maynard and Williamson, 2013). The size of the STEM education pipeline needs to be increased by implementing intensive STEM practices in schools and colleges to raise the retention rate of students joining the STEM colleges in the United States. The STEM Bachelor's degrees represent only third in the United States, while in Singapore, Chain and Japan it represents more than that ratio (Horton Gay, 2017).

The UAE is an OECD country that needs to improve it is market economic competitiveness international since it depends on it is investments on diversification of manufacturing, productivity and services fields and both demand skilled workforce.

It has been substantially noted that most students in the UAE are joining humanities and social studies fields in colleges and only 27 per cent are joining technical fields. Moreover, based on the UAE Ministry of Labor, it has been significantly noticed that the UAE citizens are not in technical and technical related professions and the majority of the citizens are working in the white-collar positions. Consequently, one of the strategies to improve the workforce is to develop the educational system due to the effectiveness of education on human capital formation (Muysken and Nour, 2006). The knowledge economics prefers the human resources with a high level of critical thinking and who can adapt to the economic future and changes or various factors that have an impact on the labour markets conditions. The education system, educators' perceptions and implementing the instructional STEM have significant effects in articulating the future workforce and contributing to productivity skills (Wiseman, Abdelfattah and Almassaad, 2016). Due to a number of economic, demographical challenges in the UAE, it has been mentioned that the UAE has economic, demographic and education challenges in the challenges. The UAE governments have initiated reforms to the education system to prepare the students with the skills needed to satisfy the labour market (Gonzalez, 2008). The OECD asserts that the country's economic development is based firstly on Education, secondly on the Infrastructure then Governance and the Institutions. Note that Education is the first element to promote the economic development of the country which is an indicator of the importance of the education quality to successful entrepreneurs to create prosperity, build resilience or recover from economic downturns. The education system must have a trajectory that articulates the targets of the education design to contribute to economic growth (Arthur, Hisrich and Cabrera, 2012).

The investment of Emirati intellect in the STEM fields is crucial to the sustainability of the UAE economy. The prerequisite to producing a skilled workforce is to take the entrepreneurship in the innovation process and allocate the resources and technology to meet the UAE environment and its community needs (Aswad, Vidican and Samulewicz, 2011).

Most Gulf Cooperation Council countries including the UAE, Saudi Arabia, Oman, Qatar, Bahrain and Kuwait the agendas and initiatives for developing the economics is to foster on the education development to change the communities from depending on natural resources to diversification in economic resources. The educational reforms are gearing the education systems to focus on establishing the sustainable knowledge-based society toward the knowledge-based economy. The education system agenda in GCC is human capital oriented that preparing for shifting the societies to knowledge societies and developing the creativity, entrepreneurial and innovation skills in young generations. To measure the performance and the shift of the societies to a knowledge-based society the UAE students are sitting for the PISA test where the school's educators are recommended to use the data for the educational changes within the school so that the school system is aligned with the international standards and recommendations of the OECD and to raise the UAE 15-years students results in the PISA test. The UAE under progress to reform the education system and rank among the 20 of the highest performing countries in the PISA test (United Arab Emirate School Inspection Framework, n.d.). The STEM education is required to develop the GCC citizens knowledge and skills to be prepared to join the labour market for any jobs that require STEM skills. From this point of view, efforts are demanded in reforming the educational systems to embedded and promote the interdisciplinary STEM education; the more STEM skills they attain while schooling the more preparedness for the prospective workforce in the GCC and worldwide (Wiseman, 2014).

This research study aims to present the international STEM best practices, investigate the STEM stakeholders' perceptions in the UAE, propose a possible STEM education model for K-12 in the UAE and to interpret the influences of the demographic variables on the STEM stakeholders. The following will outline the literature review regarding the International Best practices of STEM education, factors affect STEM stakeholders' perception and demographic influences on STEM.

1.2 Literature Review

In this section of the literature review international Best practices of STEM education and the STEM stakeholders' perceptions will be presented after revising a number of journals and empirical studies.

1.2.1 The international STEM Best practices

The best practices in educational systems have been defined as the development in curriculum, publishing educational support instruments and offering of professional developments. The evaluations of the best practices are measured by the implementation of those practices in the educational communities and introducing the instructional and the materials of the practices (Sanders, 2012).

The international best practices of STEM that have been found in the literature review for this study demonstrated the multifaceted techniques of implementing the integration between and among STEM disciplines. Some techniques advocating the hands-on activities and PBL, meanwhile the other techniques depicted the process of integrating the STEM discipline by connecting the main themes of the skills. In another study it has been indicated that various teachers' perceptions concluded that STEM has different conceptions which leads to non-unified practices in the classrooms and integrating the technology is the hardest discipline to be integrated (Wang et al., 2011).

By revising several international journals and researches it has been found that the practices of STEM education have several methods of implementations either through PBL or through preparing an integrated STEM curriculum by the collaboration of the STEM educators and authorities. STEM education for reforming the education system has been defined as the enrichment and boosting activities that are linked to the lessons taught in the classroom and relate the lessons skills to the real-life applications (Matherly, Amin and Al Nahyan, 2017).
As an example, the Model-Eliciting Activities (MEAs) has been developed in the mid of 1970 and it was called earlier as Case Studies (Chamberlin and Moon, 2005). The MEAs was developed to enable the student to interpret the scenario, model and develop their own expertise

and competencies. The MEAs have been invented for the middle schools' students and the freshmen Engineering filed students in higher education. The MEAs have been implemented as an introductory course at Purdue University and in the Air Force Academy in the US. MEAs activities are mainly correlating the engineering and mathematics educations by model and modelling to solve the authentic real-life problems; where model and modelling refers to the conceptual structure and dynamic or adaptive process that the group of students will employ to represent the solution (illustrated in Figure 2). The students can use the computer-based graphics or any interacting tool to demonstrate the solutions. The MEAs activities need one or two periods where a small group of students are engaged and productive thinkers and that can be edited

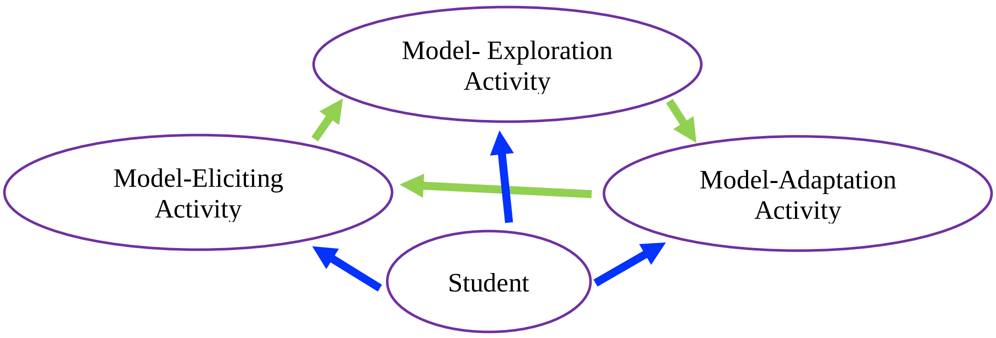

Figure 2: The Model development sequences (Lubis, pulungan and Fauzi 2017, p. 1331)

and accommodated to be appropriate for underperforming students or talented students. Paper Airplane, Quantifying Aluminum Crustal Size and the Sea Shell Island are all examples of the MEAs Framework activities that are designed to enhance the learners understanding of the conceptual models in mathematics (HAMILTON et al., 2011).

Another practice of implementing STEM is the use of big ideas to mediate the construction of integrated STEM curricula and to facilitate in-depth education using effective practice for STEM inter-disciplines explained in one of the studies. The big ideas have three types, the first type is within-discipline, the second type is cross-discipline and the third type is encompassing. The within-discipline big ideas are when the application of the STEM acts in various disciplines to represented as implementing STEM integration through a unified context. Thus, the knowledge and the conceptual thinking are expended by providing knowledge from various perspectives of STEM disciplines (Chalmers et al., 2018). As an instance, it teaches the proportional reasoning in mathematics through controlling robot movements. Controlling the robot movements teaches the learner to understand how to link the physical design of the robot to the values used in coding which lead to proportional linking and comparing of the situation of the robot in real-life to the programming and design aspects. The ability to compare and narrowing the mathematical big idea of proportional reasoning by contextualizing the knowledge within a design problem in different situation increases the metacognition skills.

The second type of employing the big ideas for STEM education integration is the cross-discipline. The cross-discipline type is to focus on a theme while teaching the skills and concepts of different STEM disciplines. The theme or the real-life issue will connect the disciplines and either one discipline or more will teach the students the concept, process or the skills related to that theme to help students to learn in a consistent learning environment (Wang, 2012). There are 10 models for implementing the cross-disciplines integration (demonstrated in table 1).

10 Cross-discipline models	Description
Fragmented model	To concentrate on one skill in one discipline.
Connected model	To concentrate on a single skill or concept.
Nested model	To focus on more than one skill within one discipline.
Sequenced model	To arrange the curriculum and make connections between the disciplines.
Shared model	To merge tow disciplines into one content knowledge.
Webbed model	To connect the units of the disciplines through an issue or a theme.
Threaded model	To teach various skills that are cross-disciplines
Integrated model	The content knowledge of more than two discipline is overlapped.
Immersed model	Each discipline addresses the interest of the learner by their characteristics.
Networked model	Trans-disciplinary STEM integration in the sense that the boundaries are eliminated between the disciplines.

Table 1: 10 models for implementing the cross-disciplines integration (Wang, 2012).

The third type of big ideas for integrated STEM is the encompassing. The encompassing is when the skills and knowledge have various representation in more than one discipline. the encompassing is the ability of the curriculum designer to analyze, design, develop, implement and evaluate the integration between the STEM disciplines. That require the collaboration of the educators during the curriculum design to exchange knowledge and perspectives on how to build an integrated STEM curriculum (McFadden and Roehrig, 2017). The encompassing can also be illustrated by investigating a problem via multi-layered and in-depth analyzing of the solution using the STEM disciplines. Integrating the curriculum can be any type of the big idea integration types or all. That because each type offers to the educator and the learner to seek the relationship among these disciplines differently.

Further studies the analyses the data revealed that the extracurricular activities like the STEM clubs have a significant impact on promoting the students' interest of STEM disciplines. STEM extracurricular activities expand the STEM education and give the learners the opportunity to widen the practice outside the classrooms as they guide the student to develop their interest toward STEM fields and careers (Garg, 2015).

Educators recognize that learning involves in places rather than the classroom like libraries, new maker-space, libraries or in any context that is structured for learning out of school. The STEM extracurricular activities grant the learners the confidence and the interest in proceeding in STEM major in the post-secondary. The STEM extracurricular clubs can include the Robotics, Science Olympiad, Math club, inviting guest speakers, conducting research, presentations and entrepreneurship, hands-on projects, competitions or any activities that the students do outside the classroom and are linked to the curriculum and real-world (Ozis et al., 2018). The schools are responsible for providing a comprehensive education for their students to prepare them for the future workforce. The STEM extracurricular activities are one of the practices to equip the students with a versatile education. The STEM extracurricular activities have been defined as the activities that are not part in of the curriculum but linked to the education and real-world by the supervision of the school to develop the student's achievements and the socialization process. As illustrated in Figure 3 the education and the work that must be the knowledge application are the 2 core values of the third core value personal developments. The students must be exposed to both the education and the work to build the characteristics of the 21st-century workforce. The experiential STEM activities are effective for the students because they grant opportunities for the relationship between the students, the exploration of wider communities of STEM-related fields and consequently increase their attention to be engaged in STEM colleges (PRICE, 2010).

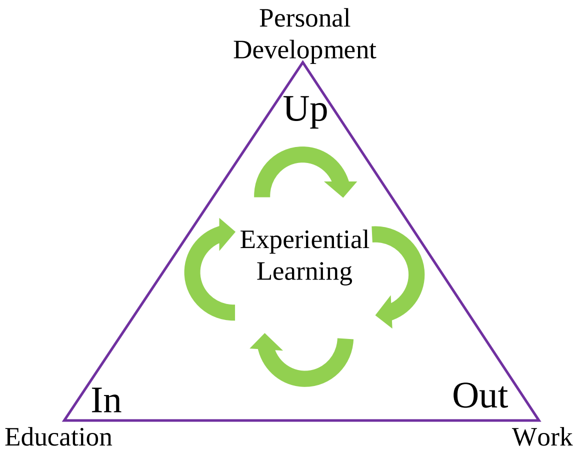

Figure 3: Experiential learning as a process to link the education, work and personnel development (PRICE, 2010, p. 10).

Further analysis indicates that students who have an interest in STEM extracurricular activities have proceeded in STEM fields (Koch, 2013). The extracurricular is evidence for students' interest in STEM fields since they are outside the classroom and they are options to be selected by the students which prove their curiosity to explore the selected extracurricular activities. The aim of the extracurricular activities practices is to draw the student's attention to further STEM fields and careers and develop their experiential skills (Cooper and Heaverlo, 2013).

Career Technical Education (CTE) is the substitute name of the vocational education and another component that motivates the STEM education. The STEM education should be merged with the CTE to prepare the citizens technically and professionally. The CTE aim to improve the students academically, technically and prepare youth to staff while they are learning. It has been asserted that 1.3 million dollars have been funded for CTE programs yearly in the US to prepare the students for postsecondary and work-based levels (MULCAHY, 2007). Legislations and supports for the vocational or CTE education have been started in the US since 1917 after the Smith-Hughes Act. That act was a result of the industrial revolution and tended to prepare the new generations for the new jobs. After decades, new technologies and have been generated and resulted in forming new careers requirements (Rojewski and National Dissemination Center for Career and Technical Education, 2002), consequently legislation has been issued for new reforms in education to standardise the education systems with the next generation of job opportunities (Figure 4 indicating the timeline of the U.S federal legislation and the reforms in education to embed the CTE in the educational system). In short, the economic and industrial developments have a direct impact of reforms in the education to prepare the next generation for the new challenges in the career markets.

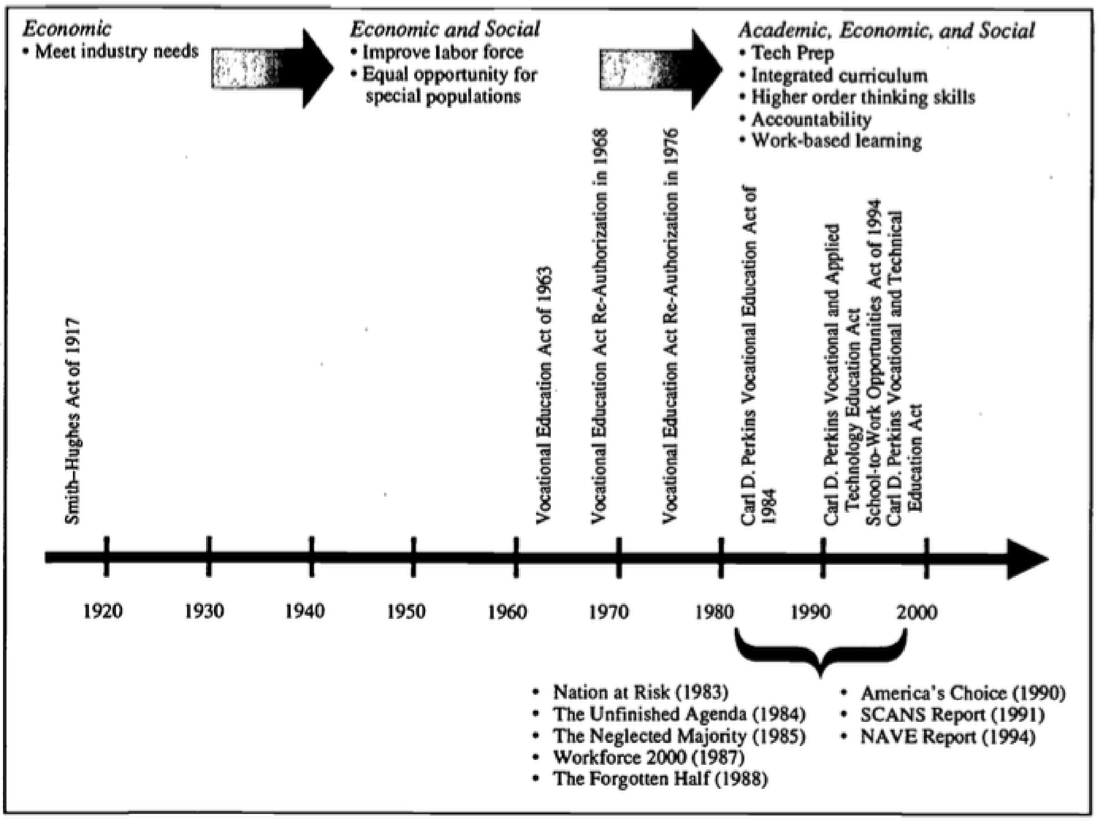

Figure 4: Indicate the time line of the U.S federal legislations and the reforms in education to embed the CTE in the educational system (Rojewski and National Dissemination Center for Career and Technical Education, 2002, p. 14).

Merging the academic education with the CTE programs will be effective to raise the performance of the students (Kantrov, 2015). CTE programs have a significant role in preparing the students by skills for occupations. In the sense that students gain the academic, communicative competence, technical skills and understanding to the career pathways to proceed consciously for a college relevant to the anticipated workforce and their tendency (KEYLON, 2014). The vocational education or the CTE grant the students to grasp education in contextualized to real-life careers that immediately correlated to the preparation for the advanced degree (SALVADORE, 2016).

The Office of Vocational and Adult Education and the National Association for State Directors of CTE Consortium recognized the 16 career groups (see appendix 1) that ought to be integrated with the education curriculum and instruction to transfer the students of 10-12 from high schools to college and career life (Jocson, 2015).

Despite some curricula being integrated, educators in schools have been requested to implement the STEM education and embed the technology and engineering in classrooms instructions, although not all the teachers are engineers or aware of technology skills. For these reasons, educators are requesting for professional developments by the local leaders to address the interconnectedness that should be built by the STEM disciplines and to identify the 4Ps model (see appendix 2) which include the purpose of STEM, Policy of STEM, Programs and Practice. 4Ps will help STEM stakeholders to formulate the constraints and challenges of STEM education and create an action plan to implement it (Bybee, 2013).

Mediating the professional development (PD) to the educators and students for implementing the STEM education will facilitate the perceptions and the implementation. the professional development as an on-going practice in educational systems will preserve the educators and students to be updated and increase their knowledge by exposing them to new approaches of the STEM contents. Moreover, the PD meetings consolidate the reciprocal relationship and experiences among the STEM stakeholders' educational communities. Educators in PD exchange skills designing, tailoring and implementing STEM lessons and PBL and the learning styles in the classroom in addition to the classroom management. A study indicated that PD within one of the high schools in US are implement in weekly basis to advances the utilization between the educators and train the new staff by the master staff, as well as, year-round PD in which the educators are attending PD summer camp for a tremendous number of educators from different cities to share their academical experiences among the academic year (Gourgey, Asiabanpour and Fenimore, 2010).

The existence and the intervention of the authorities, governments and association of the country to reform the education are significant to transfer the appetite and the characteristics of the desirable future workforce based on the country demands. The intervention can be done by PDs and workshops for the educational system and especially regarding STEM education.

As an effective practice of the ITEEA in US educational systems reform, it has developed a panel illustrating the CTE and infrastructure and has been presents in the Russel Senate office in Washington (Valenzuela, 2018). The ITEEA representative discussed and explained the panel to the education systems leaders. The ITEEA panel focuses on CTE and STEM education by merging the educational practices to any career demands and the illustrated the extensive range of support that will be provided by the federal policy to support the reforms (Register Now for the 2017 Integrative STEM Education Professional Learning Community, 2017). Finding of one of the researches revealed that the PDs advocated by the Science and Engineering National Academies and the Institute of medicine have a positive impact of the STEM teachers' conceptions, meaningful contents and practices of STEM integration (Singer, Ross and Jackson-Lee, 2016).

For any new education or career pipeline, educators require training and workshops to recognize trends and methods to implement and deliver learning outcomes for students (Vennix, Brok and Taconis, 2016). Those experts in charge of providing the workshops and the PDs and resources for the educators can be provided by the Energies authorities, Industrial sectors or governments to elaborate upon the latest updates in the field and the methodologies and resources vital to prepare the pupils for the future challenges. As a practice of providing PDs by the external institution for the educators is the intervention of environmental authorities in the US to establish the environmental educational discipline. The interventions were thorough providing professional development opportunities for education stakeholders to identify key environmental literacy and environmental programs (To, 2016).

Some initiatives in the UK for advancing teacher STEM education practices were provided by the National Learning Center and Network STEMNET which is conducting continuous PDs for educators. STEMNET supports educators into to manage STEM clubs in schools, coordinate outreach activities and guide educators to utilize STEM resources in classrooms. Although the external interventions for reforming the educational systems are significant and enrich the STEM curriculum activities, it has been claimed that the policymakers are not supporting the educators in providing workshops and PD for defining the strategies of implementing the STEM education. Outreach program and PDs are practices for benefiting the students and educators to be engaged to STEM real-life scenarios. Unfortunately, educators are not experts or equipped in facilitating the STEM activities and the policymakers advocating the STEM education are still inadequate (Aslam, Adefila and Bagiya, 2018).

The outreach of schools supports for implementing and fertilizing the STEM education can be conducted by any STEM external entities or stakeholders. It has been mentioned that the schools ought to arrange meetings with industries and postsecondary STEM stakeholders to mentoring programs, instructions and authentic connection of the STEM disciplines as for the students to master the STEM interconnectedness is fully dependent on the educators and the school preparation (Designing Multidisciplinary Integrated Curriculum Units, 2010). Despite that all arrangements for STEM implementation require funding, time and educational administrative support. In a sense the PD educators and for educational reforms are supposed to be sponsored by academic and non-academic organizations to fulfil the future STEM workforce demands (Gail Richmond et al., 2017).

As far as federal governments initiatives to provide workshops and PDs to promote STEM education, the Accreditation Board for Engineering and Technology (ABET) and the Aerospace defence industry in the US have co-operated with the government to offer programs that encourage students for STEM education. The US policymakers advocated that it is the responsibility of the federal government, business sectors and the educators for the students' STEM readiness. It has been asserted that the funding to promote STEM education in the US has exceeded 4.3 billion dollars for offering workshops, PDs, resources and mentoring opportunities (JOHNSON-OLIVER, 2014).

The ABET program impels three outcomes that must be met by the technology and engineering graduator which are the abilities of effective communication, solving engineering problems and working on a multidisciplinary. Those criteria of ABET cannot be achieved by informative lectures or closed form of a question but are strongly appropriate and fulfilled by STEM PBL education (Bishop 2013).

The schools that seek to implement STEM education are usually striving to cooperate and create a relationship with industries, business and universities to build the STEM curriculum. The cooperation can include arranging workshops and PDs for educators and students and provide mentorships and internship opportunities for the students which expose the school's communities to careers and link the education to the application in real-life (WHITE, 2015).

Figure 5 is a model for the steps that followed by teachers of high school for tailoring the integrated STEM curriculum based on big ideas or themes that have been agreed with the STEM stakeholders (Designing Multidisciplinary Integrated Curriculum Units, 2010).

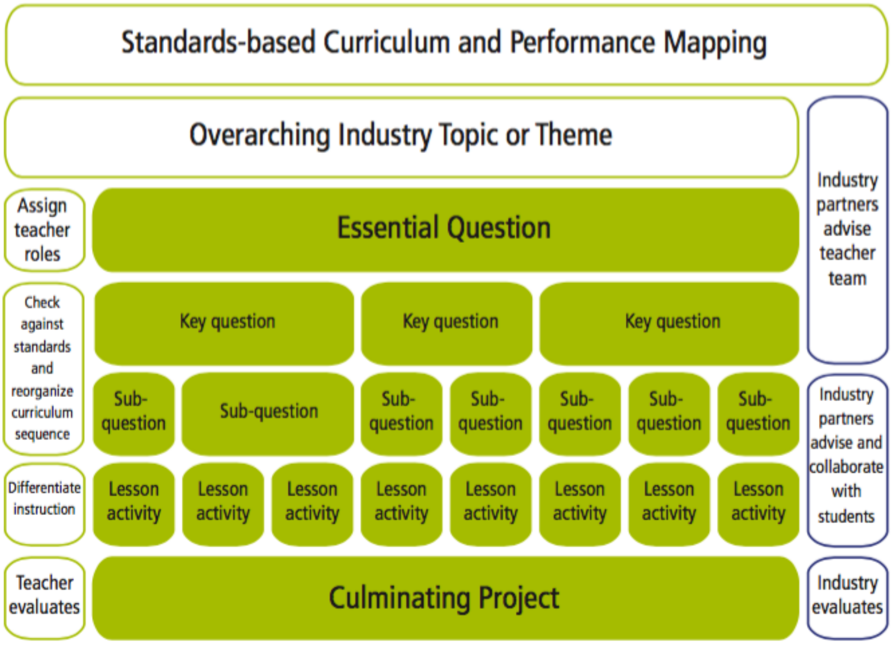

Figure 5: Model for the steps of implementing the integrated STEM curriculum (Designing Multidisciplinary Integrated Curriculum Units 2010, p. 7)

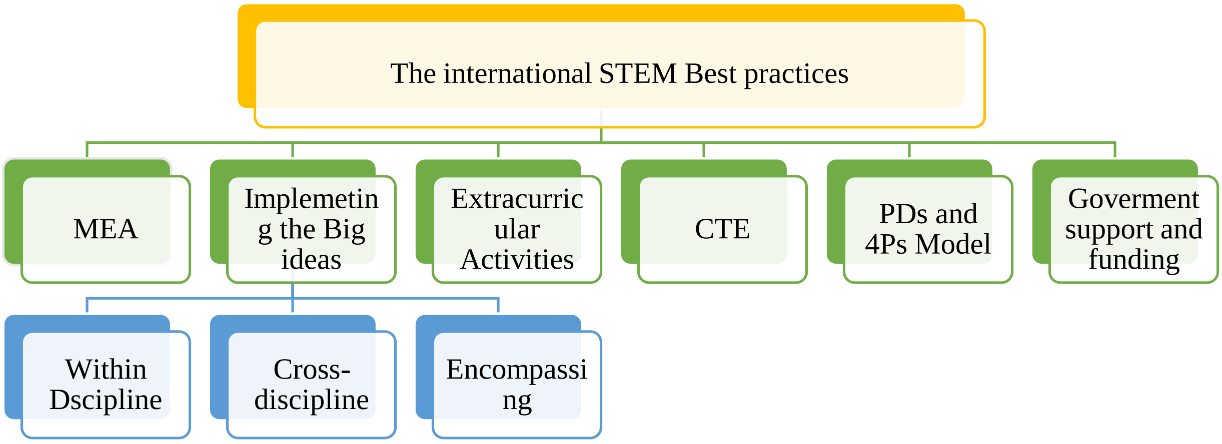

Figure 6: Summary of the International STEM best practices

1.2.2 Factors affect STEM Stakeholders' perceptions

STEM stakeholders, as defined earlier in this dissertation, are the STEM educational and non-educational communities including governments, business, industries, parents, students and educators who are immediately or eventually have effects the STEM education, practices and development. The involvement of the STEM stakeholders in the process of implementing the STEM education is significant and effective as their involvement and cooperation will provide a range of ideas, real-life contexts and varied experiences that are mapped for integrating the STEM curriculum (SUNNY, 2018). Despite that, STEM education has the priority as educational policy (To, 2016), the practices of STEM education are multifaceted based on the stakeholders' perception of STEM education. As for reviewing the literature, the practices of STEM were varied and did not have a unified framework. Internationally the education stakeholders' perceptions and beliefs are valuable for investigating their understanding and implementation of the educational policies. For example, the OECD has launched the TALIS survey for educational stakeholders, especially the teachers and principals of the partners countries, to compare their perceptions, performance, range of collaboration between the school administration and teaching staff, the number of workshops and professional developments they receive, the extent of teachers' job satisfaction and investigate the measurements of teaching and learning quality. Based on the TALIS survey results, further policies and recommendation can be issued or amended on the international levels to reform education (Burns and Darling-Hammond, 2014). Thus, asserts the importance of the educational stakeholders' perceptions in developing and implementing educational instructions and policies (Johnson, 20112. In a study that has been conducted in Scotland the results revealed that teachers' practice and methods are significant for reform the educational policies and is considered as a legitimate bottom-up style for promoting educational policies (Wallace and Priestley, 2011).

The second research question of this dissertation is to investigate the STEM stakeholders' perceptions of the UAE. The two surveys that have been designed and used for collecting data contain questions that will help in investigating the STEM stakeholders' perceptions in some UAE industries and schools in Dubai and the factors that affect these perceptions.

In this section of the literature review the factors that affect the stakeholders' perceptions toward STEM education will be outlined.

Currently the perception of the integrated STEM curriculum is to correlate the standardized STEM disciplines subject contents areas.

It has been asserted that teachers' perception and understanding of STEM education directly reflect their attitude to tailor and integrate the STEM curriculum. The teachers' perceptions for integrating STEM disciplines are affected by intensive professional developments that demonstrate examples of ways for connecting the STEM disciplines contents, means by more practical examples for integration (Wang et al., 2011). In addition to the STEM-focused professional developments that affect the teacher perceptions, it has been mentioned that, the teachers' level of job satisfaction affects their autonomy in handling challenging task and implementations of policies (Ernst et al., 2018).

The different conceptions of STEM education by government and other leaders affected the consistency of the implementation, funding for the STEM programs and the provision of PDs that motivate the STEM education (Johnson-Oliver, 2014).

The STEM stakeholders' interests and beliefs in STEM education are not sufficient for effective implementation. It has been confirmed that 80% of the teachers agreed that external entities workshops such as universities, industries or any STEM outreach program influenced positively of their STEM beliefs and the way of translating those beliefs into practices and actions or at lease provide them new ideas for implementing STEM in their classrooms (DeCoito and Myszkal, 2018). In a sense, to motivate the educator's STEM conceptions and encourage them to practice STEM education in classrooms, the encouragement must be by the leadership, the higher education and STEM industries by exposing them to practices and real application of STEM.

STEM educators indicated that the implementation of STEM requires more prior planning and preparation before the teaching and learning time in classrooms (Gourgey, Asiabanpour and Fenimore, 2011).

Stakeholders encompass the government's leadership who are dedicating a financial budget for the educational reforms in the country. The investments for educational reforms include curriculums reforms, PDs for teachers and students and intervention of STEM Industries such as energy providers to support the educational system, implements the vocational STEM and invest in education to prepare the future employment (Breiner et al., 2012).

The second research question in this dissertation is to investigate the STEM stakeholder's perception of the UAE. The UAE education reforms as having been transferred from governmental higher levels to the educational institution and school or lower levels. In the sense that the educational policies can be formed from the lower level practices and experience (Al-Taneiji and McLeod, 2008). The UAE took several advocates initiatives for promoting the implementation of STEM education through workshops, competitions, symposiums and exhibitions. Sheikh Mohammed bin Zayed, Crown Prince of Abu Dhabi and Deputy Supreme Commander of the UAE Armed Forces mentioned in the Mohammed bin Zayed Majlis for Future Generations that the knowledge of technology, engineering and finance are important the information-economic revolution in UAE. The UAE is shifting from an oil-based economy to a knowledge-based one whereby the employment pipeline is changing and requires more scientists and engineers (The National, 2018). The Crown Prince of Abu Dhabi is encouraging UAE students to join scientist and engineering fields. Although the UAE has tremendous initiatives toward STEM education in the UAE, students are not joining the STEM fields which lead the researchers in the UAE to encourage educational systems to have STEM-capable teachers that are able to deliver the STEM curriculum to the students and motivate them to pursue in STEM fields and careers. In a study in the UAE 60% of the student's perception agreed that their teachers are to some extent capable in STEM fields. It is essential to increase this percentage by improving the quality of teachers to increase the registration of UAE students in STEM fields (Makhmasi et al., 2012). UAE students' perceptions have revealed that the teacher capabilities, the language of instruction and the absence of STEM role models are all reasons that affected their choices to select STEM majors in higher education (Alyammahi et al., 2016). To encourage the STEM education in the UAE investment funding for this reform ought to be provided by PDs for the educators, updating curriculums, increasing the educators' wages and prepare strong educational and schools' leadership ought to be considered in the educational systems. Educators wellbeing, the opportunities of advanced PDs for the educators, updating the educational resources and strong educational leadership will all reflect on the response of the educators to implement the required methods, to enhance teaching and learning process in the classrooms and to innovate in the teaching methods including the cross-curriculum and STEM education which will all reflect on the students education which are the products of the future workforce in the UAE. It has been asserted that "The research conducted by Hills and Flesher indicates that an investment in workforce development through education is the key to economic and technological development in the UAE" (Zahran, Pettaway, Waller and Waller, 2016, p. 5). PDs for educators, resources for classrooms, curriculum development and the considering the educator's wages to prepare the teachers to be more effective in the classrooms which will affect the student's enrollments to STEM faculties in the stage of post-secondary (Alyammahi, Zaki and Barada, 2016).

The educational resources providers in the UAE are another entities or stakeholders that affect the STEM education in the UAE. The governments or private sectors preparation of classrooms and environments include the STEM resources and STEM labs or maker-space. Educational companies in the UAE such as Edutec and ATLAB are leading education companies for preparing the schools with STEM resources, learning solutions and provide workshops for educators and students (Mahil, 2016). It has been mentioned that "With mounting international competition for STEM-related jobs, federal, state, and local authorities are doubling their commitments to strengthen student preparation and recruitment in STEM areas" (Maguth 2012, p.66).

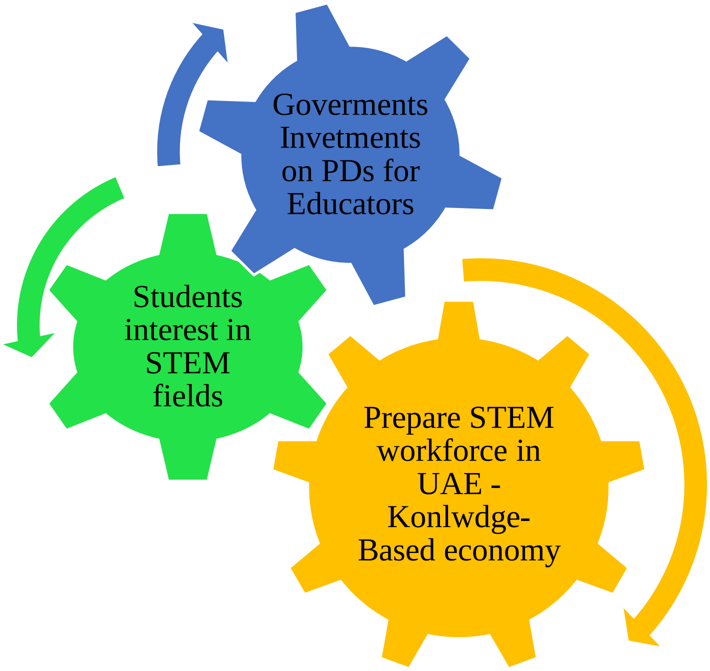

Figure 7: The Process for preparing STEM workforce in UAE

The UAE educational governments stakeholders' perceptions make them highly aware that the PDs are significant for educators lifelong learning, filling the gaps in the skills and updates. The PDs for educators are crucial for the quality of learning environments which in turn affects the student education. The UAE participated in two TALIS surveys and according to TALIS survey results, educators required ongoing PDs activities to reform the educational system and provide the training for educators to implement the educational policies for reforming the educational system and preparing the future workforce (Badri et al., 2016). The analysis of the survey data revealed the extent of UAE stakeholders' perceptions about interventions by Industrial authorities to support STEM education.

1.2.3 Demographic influences on STEM

The demographic influences on education have a substantial impact on implementing STEM education and the preparation of future workforce stock. The demographic aspects or variables (Figure 8) of this study included stakeholders' gender, qualification, educational environment and the number of practices that have been performed toward STEM in school and result on increasing STEM readiness and preparation to join STEM colleges (Naresh, Sree Reddy and Pricilda, 2016).

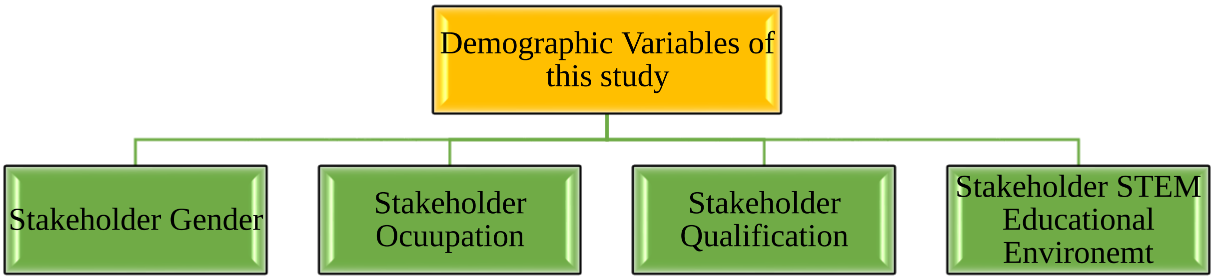

Figure 8: Demographic variables of the study

The demographic factors have major influences on the student's selection for the STEM fields, the teachers teaching STEM subjects and any stakeholders participating in the process of STEM education. As in instance, several studies revealed that the male students have more tendency to join STEM colleges that females and the demographic aspects and pre-college preparation have an important impact on students' decisions whether male or female to join STEM colleges (Crisp, Nora and Taggart, 2009). In addition, many types of research asserted that females are a minority in joining STEM filed comparing to males (Moakler and Kim, 2014). Another study mentioned that student's confidence in STEM areas in school education affect the student's future in post-secondary education.

Gender differences play roles in education and careers. Differences among genders in attainments in education will reflect their career pathway and joining of faculties. In the coming decades the needs of education and high skills are important for economics, thus, the recruitment might be affected by gender inequalities in workforce participation. It has been mentioned that females have higher attainments in education rather than males and that there is a gender gap in education which will affect the employment in the future (Bernasconi, 2017). On the other hand, the males prove high skilled workers in industrial revolution after World War II which is opposite to the requirements of the future workforce skills that is a knowledge-based economy. In conclusion although females have higher attainment in education, the males joining STEM fields are more compared to females. In counterpart study that focused on STEM education, the analysis revealed that the male students have a higher interest than females especially in engineering courses which shows that 5.6% males students earned credits in engineering compared to 1.1% of female students' credits (Bernasconi, 2017).

That implies that although female students might have higher educational attainments, however, the male students tend to join STEM course is further than female. Stoeger et al. (2013) find that males' interest in STEM subjects and extracurricular is three times higher than girls. The females show underrepresentation in STEM majors in contrast to males which increases the attention to bridge the gap in STEM education (Price, 2010). For that reason, educational policies have been placed to bridge the gaps between gender differences in education and prepare for equity in future employment (Andersen, Roine and Bratsberg, 2016). The school pathway curriculum and CTE programs are opportunities in schools' systems to motivate students for joining STEM fields and bridge the gap. The CTE program as in has been mentioned earlier, focuses on preparing the school students for a knowledge-based economy and expose them to the essential skills for the future workforce by embedding the CTE programs in the academic education system and curriculum.

Finally, since CTE program invokes the occupation related to STEM and promote the knowledge-based skills economy, then it is important to the education system to prepare the resources and the educational environments to expose all the students and achieve the equality in workforce and advancement in the coming future. One of the aims in this study is to investigate the demographic variables and it influences stakeholder's perception and decisions toward STEM practices and to join STEM fields (Fletcher, 2012).

CHAPTER THREE

METHODOLOGY

The present study investigated the stakeholders' perceptions of best practices of STEM education in order to propose an appropriate STEM education model for K-12 in the UAE. This chapter will extrapolate the study design and methods including the site, study instrumentation, sampling and participation, and ethical consideration. It also describes the validity and reliability by computing the Cronbach's Alpha of the data and give details on the ethical consideration.

2.1 Study Design

The hypothetical foundations of this study are believed to be practical, as it aims to identify best practices of implementing STEM education in K-12, particularly in high schools as it is the preparation for the post-secondary stage in the UAE. The study will apply a quantitative approach to collect data and data analysis by using quantitative tools. The data analysis will be explained to provide answers and interpretations for the study topic and research questions (Cresswell 2011; Laban 2012). Performing quantitative methods in this study follow the post-positivistic paradigm that entails gathering data via close-ended questions concerning STEM education best practices in schools and by obtaining generalization and recommendation after analyzing the data (Cresswell 2002; Laban 2012). Analysis of hypotheses is used inductively to build and validate a theory. At this point, the existing theories that are related to the research problem will be presented and analyses. The theoretical foundations will provide the interpretation of the relationship between the variables in the study problem. The deductive method will be used to investigate the perceptions of stakeholder regarding the STEM practices that may affect in proposing an appropriate STEM education model in the UAE (Laban 2012). The quantitative questionnaires offer data concerning present perceptions and practices of STEM education from STEM stakeholders (Teachers, Head of STEM departments and STEM Partnership from Energy authorities and the Industrial sector in the UAE) and high school students, which answers the research questions. Generally, the research topic reflects the independent variable (Stakeholders and students' perceptions), the dependent variable (Best practices of STEM) and the demographic studies in the UAE. The dependent variable is the problem variable and the independent variable has a relationship with the problem and if it has been efficiently handled will definitely support desirable changes in the variable of the problem (Nenty, 2009).

2.2 Study methods

Obtaining the students' and stakeholders' perceptions are one of the best tools for tracking the usefulness of STEM education implementation in the schools. The questionnaire is appropriate for measuring the consistency of implementing the STEM education and providing a proposal of the insight instructions and proposal for a model to support the implementation of STEM education (Abell & Lederman 2010). The investigation of STEM best practices was based on the 44 survey questions assessing perceptions, practices and demographic influences on STEM best practices in the UAE. The calculation of those questions as dependent variables was done by weighted Likert-scaled questions of two surveys (Students' survey and Stakeholders' survey) (Ozis et al., 2018). To use the information common between the students and the stakeholders, two surveys were designed to collect the perceptions of the students and stakeholders as both have different perceptions of STEM education. Students' perception is investigated through the awareness, understanding, applications and future plans toward STEM faculties and careers. Meanwhile, the stakeholder perceptions were investigated by the methods of implementing and motivating students toward STEM fields (Gil-Izquierdo and Cordero, 2018). The following were the data collection steps:

1. Quantitative data survey, "Survey for Teachers, HODs, Principals and STEM partnerships, (Energy authorities and the Industrial sector in the UAE)" was used to identify STEM stakeholders' perceptions and practices.

2. Quantitative data survey, "Survey for Secondary School Students", was used to identify students' perception of STEM education and the influences of it towards STEM fields in postsecondary.

To investigate the STEM Education practices perceptions in high school education, it is important to discover the implementation from different angles. Any educational statues ought to be investigated by students' and stakeholders' point of views and actual practices.

2.2.1 Context

The study was conducted in a private school in Dubai city in the UAE that applies the American curriculum. The stakeholders were the HODs and principals and some outsource providers they supply resources and individuals form the UAE industrial sector and energy authorities. The purpose for selecting that school is the implementation of STEM education for K-12; the courses of Technology and engineering were offered to high school students (10-12) since the last 2 years (Grade 10 students have been covering STEM for 2 years) and the alignment of the curriculum with the international standards. The students graduate from that school are attending universities in UAE and abroad. These reasons correspond to the purpose of the study to investigate the STEM stakeholders' perception regarding STEM best practices in the UAE in order to propose a model for STEM education.

Data collection for the students' survey was performed during the academic year. For the STEM stakeholders, the data was collected at the end of the academic year.

2.2.2 Study instruments

The nature of this study requires a quantitative method with two different instruments. The quantitative data was collected via students and STEM stakeholders' responses to the questionnaires that were used to define their perceptions concerning the STEM education in the UAE and best practices.

2.2.2.1 Students Questionnaire

Students' questionnaire (see appendix 3) is a quantitative description tool to measure the perception of the students regarding the STEM education practices and the influence of STEM education on joining STEM filed in post-secondary education. The tool consists of three parts; the demographic, the perception, and the practices of STEM. The survey questions for students were modified from the survey developed by Hillman et al. (2016). The questions were modified to collect constructive feedback from the students understanding and practice of STEM education. The questionnaire investigated the high school students of grades 10 to 12 regarding the STEM education, workshops, engineering courses, STEM labs, and fairs and the responses which will support building a proposal of STEM education model (White, 2015).

2.2.2.2 STEM Stakeholders Questionnaire

The quantitative questionnaire concentrating towards teachers, HODs, Principals, STEM partnership in Energy authorities (For e.g.: DEWA) and industrial sectors (For e.g.: EGA) to investigate their perception regarding STEM and the best practices to implement STEM education (Abell &Lederman 2010; Bell 2010; Cohen Manion& Morrison 2000; Cresswell 2002; Cresswell 2011). The questionnaire was designed to answer the STEM stakeholders' part of the research questions (see appendix 4). The formal survey (Kezar and Gehrke, 2017) consists of three parts. First, demographic to identify the stakeholders' gender, age, and proficiency. Second, the questions that focus on the perception. Third, the questions that focus on best practices and help to propose the STEM implementation model which were adopted and modified from NSFA STEM education survey (Surveymonkey.com, 2018), which identified the requirements of STEM stakeholders' perceptions regarding STEM education. The STEM stakeholders' questionnaire includes demographic criteria, collecting perceptions and investigate practices to construct a model of STEM education. The demographic criteria investigate the experience and satisfaction of the individual in their job to investigate the stakeholders' conditions (Zhou, 2013). The questions also investigate the teacher perceptions in regard to IBL as a critical method for STEM education (Gourgey, Asiabanpour and Fenimore, 2010). The stakeholders were asked through the survey about the STEM PDs and workshops offered by the energy authorities and industrial sectors to promote STEM education (Gourgey, Asiabanpour and Fenimore, 2010). In addition, the survey investigates whether the school is offering the CTE curriculums as part of the academic training (SALVADORE, 2016).

The validity of the survey was checked by a university professor who advised to change some points to make the survey more appropriate to the contextual conditions.

2.2.3 Participants

Participation consisted of two groups: students and STEM stakeholders (HODs-Principals- Energy authorities or Industrial sector in the UAE). Students were from high school 10-12. STEM stakeholders participated from different STEM partnerships in Dubai. The method of choosing the students was based on purposeful sampling (Creswell, 2009). The 88 students in grades 10-12 were chosen as they were preparing for the post-secondary stages and they are expected to obtain STEM skills, knowledge and decide for the future STEM fields and career. The students are attending the core subjects in math and science. However, some students have elective courses for STEM disciplines like engineering, design and technology and, advanced courses in science and math. Invitations were sent to the students and STEM stakeholders and the responses were compared to address the research questions.

2.3 Ethical consideration

Official permission from the school, some authorities and industrials were granted to the researcher to conduct the research and collect the survey data (Bell 2010; Cresswell 2011). Moreover, the researcher sent an official email to all participants (see appendix 5) to explain the aim of the research, and to guarantee that all the responses and data will be used for the research purpose only and will stay confidential (Bell, 2010). The student and STEM stakeholders did not provide their names or locations; consequently, the anonymity was protected. Moreover, it didn't enable to identify the individual participants by the researcher (Bell, 2010). Martin et al. (2005) mentioned that ethical principles are integrity, competence, professional and scientific responsibility, people's rights and dignity, and social responsibilities. Based on that, the ethical issues have been considered in steering this research. Informed consent was obtained in which participants were given an informed voluntary option to participate in the study. The privacy of the participants' perceptions and beliefs were respected and confidential. Following the research design and the data collection, the next chapter will present the results and analysis of data.

CHAPTER FOUR

RESULTS AND ANALYSIS

The purpose of this study is to investigate students' and STEM stakeholders' perception and practices of STEM education. This chapter presents data collected in order to answer the study questions that is the quantitative results of questionnaires of students and stakeholders are.

3.1 Demographic information

Two different tools were used in this study. Students' questionnaire which was sent to 360 students from grades 10 to 12. 88 students responded, whereby 33% from grade 10, 46.5% from grade 11 and 20.5% from grade 12. They were distributed across female and male sections of which 64.8 % were males and 35.2 % female students.

The STEM stakeholders' questionnaire was sent to 100 individuals from different STEM partnerships including schools, energy authorities and industrial sectors in the UAE. What 25 of them responded were 11% male and 56 % female. 28% of those who answered were Head of Department, while about 40% of them educators, 8 % Engineer or Trainer in STEM Institute and 24% were Engineer, trainer or Employee in Energy authorities or Industrial sector in the UAE.

80% were satisfied and motivated in their jobs and 92% of them were engaged.

3.2 Quantitative results

The reliability test SPSS analysis was used to locate Cronbach's Alpha, demonstrated in table 2 below (Frankel, Wallen& Hyun, 2015).

Reliability Test		
Reliability test for students' questionnaire is (**Reliability Statistics**)		
Cronbach's Alpha	N of Items	Description
.671	20	Cronbach's Alpha = 0.671 < 0.7 but it's very close to it, we can assume the data are reliable.
Reliability test for Stakeholders' questionnaire is (Reliability Statistics)		
Cronbach's Alpha	N of Items	Description
.760	22	Cronbach's Alpha = 0.760 > 0.7 we can assume the data are reliable.

Table 2: Reliability Test Results

The data collected was used to answer the following research questions:

- What are the best practices of STEM education as presented in the Literature Review.
- What are the stakeholders' (Students-Educators- STEM partnership (Energy authorities and the Industrial) perceptions regarding STEM education in the UAE?
- What is a suitable or appropriate STEM education Model for K-12 in the UAE?
- What are demographic variables influences on stakeholders'?

Several best practices regarding the implementation of STEM education were reported from the data collected and will be compared and discussed with the best practices in the literature review in the chapter discussion, conclusion, recommendation and limitations.

3.2.1 Students' perceptions of STEM education practices

Students' questionnaire was designed to recognize students' perceptions of STEM education practices and how they are going to reflect on students' decisions for the post-secondary fields and future career decisions. 71.6% of the students confirmed that STEM education had been introduced in the school as per to figure 9 that represent the responses of item 3.

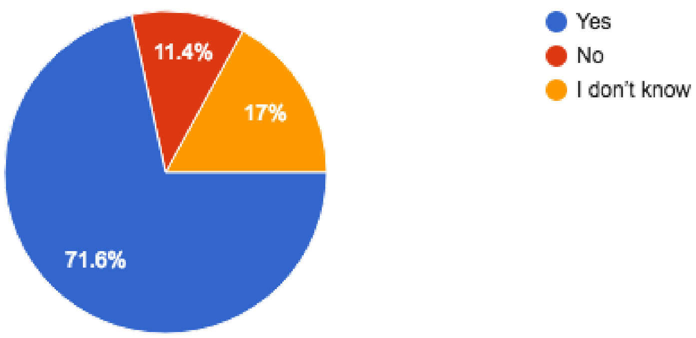

Figure 9: Students' responses to item 3

The percentage number of responses per items that investigate the STEM perception and practices are presented in Table 3.

Question	I don't know		No		Yes	
	#	%	#	%	#	%
5 Do you have new science and mathematics requirements or courses (Elective Courses-New Resources/Materials/Tools)?	34	38.6%	17	19.3%	37	42.0%
6 Does your school offer engineering courses or projects?	16	18.2%	42	47.7%	30	34.1%

7 Is there more time for teaching science at your school as a result of STEM?	28	31.8%	36	40.9%	24	27.3%
8 Is there a dedicated STEM lab at your school?	20	22.7%	32	36.4%	36	40.9%
9 Have you been in STEM camps/clubs such as environmental, sustainability or machine learning camps or clubs in the school?	10	11.4%	64	72.7%	14	15.9%
10 Is technology used throughout your STEM program as a tool to facilitate research, investigation and design?	11	12.5%	23	26.1%	54	61.4%
11 Is computer science considered part of the STEM education in your school?	18	20.5%	23	26.1%	47	53.4%
12 Do you have teachers in your school who are certified in STEM?	42	47.7%	18	20.5%	28	31.8%
13 Are workshop opportunities around STEM regularly provided to students in your school by STEM agencies (Energy/Investment/Companies authorities)?	34	38.6%	29	33.0%	25	28.4%
17 Did you consult with any local businesses/authorities, or individuals from businesses to help you prepare your STEM project?	0	0.0%	63	71.6%	25	28.4%
18 Are you planning to major and considering a career in math, science, technology, or engineering in college?	22	25.0%	14	15.9%	52	59.1%
Overall Total	235		361		372	
Total of all the responses	968					
Percentage of the students' responses	24%		37%		38%	
Question	**Disagree**		**Not sure**		**Agree a lot**	
19 Apply what we are learning to our daily life.	13	14.8%	36	40.9%	39	44.3%
20 Talk about the types of jobs and careers that use STEM.	13	14.8%	44	50.0%	31	35.2%

Table 3: Overview of students’ responses to items regarding STEM education practices

Although 71.6% of the student’s response indicates that STEM education has been introduced in the school, the results indicate that not all the STEM practices are implemented by the students. However, 59% of the students are planning to join STEM fields after post-secondary school. Additionally, it is obvious table 4 that the students’ responses about having STEM lab in the school were categorized into two major groups: about 36.4% of the students reported that they don’t have STEM lab, whereas 40.9% reported that they have the STEM lab and 22.7% reported that they don’t know. Regarding the STEM workshops provided to students by external entities like energy authorities, only 28.4% of the students reported that they attended STEM workshops. Looking at the item of applying the learning to daily life, 44.3% of the students agreed on a lot while 35.2% agreed on a lot regarding connecting the types of jobs to STEM.

Figure 10 revealed that the students are conducting STEM fair PBL in as a group.

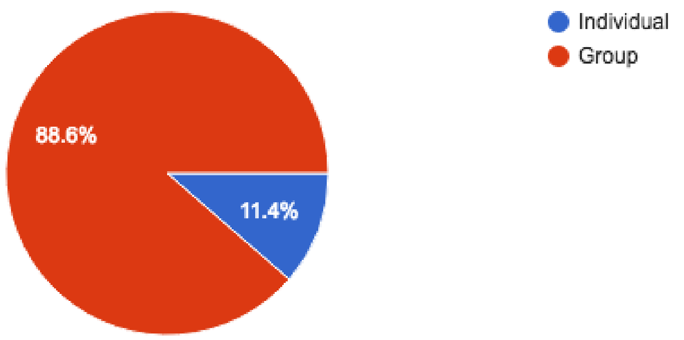

Figure 10: Students' responses to item 15

Figure 11 is the pie chart demonstrates item 21 responses that reveal the students' interest in being involved in a career. Students prefer to find details about the work in STEM technical fields followed by learning a trade at the company.

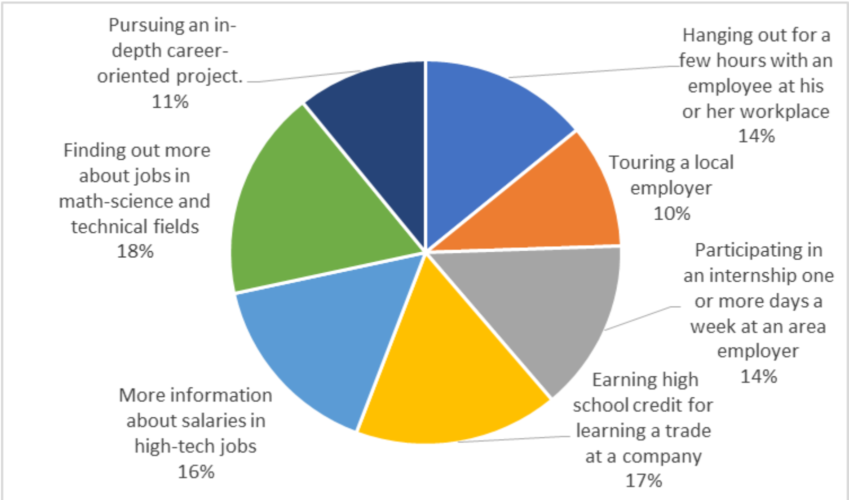

Figure 11: Students' responses to item 21

On the other hand, three-quarters of the students are planning to proceed in a four-year college for post-secondary (see figure 12).

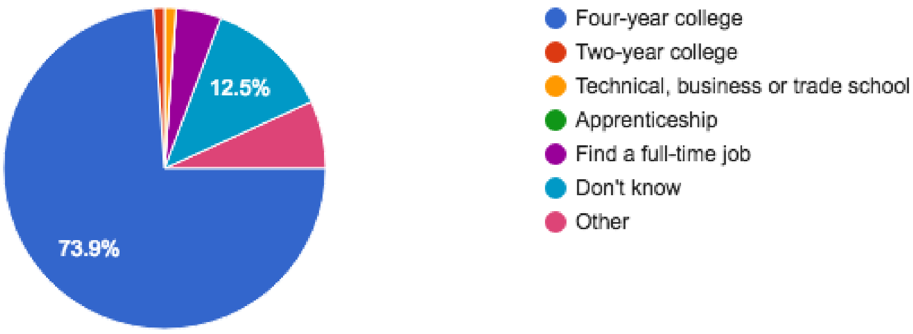

Figure 12: Students' responses to item 21

After analysing students' responses to a particular item of STEM Best practices, students' responses revealed that one-third of the students reported that they were exposed to the STEM education in the school but not all the practices were implemented, however students show interest to proceed in a four-year college and to join STEM fields as a career.

3.2.2 Stakeholders' perceptions of STEM education practices

The stakeholders' questionnaire was designed to investigate the stakeholders' perception and practices regarding STEM education in the UAE. demonstrates the percentage results of the stakeholders' responses for STEM perception and practices.

Question	Not Applicable		Strongly disagree		Disagree		Agree		Strongly agree	
	#	%	#	%	#	%	#	%	#	%
6 The STEM education (e.g. programs, courses, certification or workshops) has been introduced in your institution, school or city.			2	8%	9	36%	7	28%	7	28%
7 I enjoy preparing lessons plans, teaching and preparing activities on a team with educators of STEM disciplines.	10	40%	1	4%			6	24%	8	32%
8 I am comfortable using a problem-based and project-based approaches in education in my work.	7	28%	2	8%			9	36%	7	28%
9 A hands-on and minds-on approaches to STEM education is the best way for students to learn science and build crucial			2	8%	1	4%	11	44%	11	44%

science literacy skills, such as critical thinking, problem-solving and the ability to work in teams.										
10 I enjoy revising the STEM curriculum on a team with other teachers and modifying it to be integrated and content synchronized regardless the skills will be taught in each discipline.			1	4%	9	36%	10	40%	5	20%
11 I believe that a problem-based and project-based approaches to STEM curriculums can lead to students missing the learning of important basic facts.			3	12%	10	40%	5	20%	7	28%
12 I believe that a problem-based and project-based approaches to STEM curriculums help students to think critically.			2	8%	1	4%	14	56%	8	32%
13 Energy authorities or Industrial sector in the UAE involved with STEM education in your city or school.					7	28%	14	56%	4	16%
14 The STEM curriculum in your city/school is multidisciplinary and it includes lessons that are integrated (to include math, science, technology, and engineering).			1	4%	9	36%	11	44%	4	16%
15 Professional development opportunities around STEM regularly provided to educators and students in your city or school.					16	64%	7	28%	2	8%
16 Students in your city/school regularly involved with math, science, engineering or career and technical education (CTE) competitions.					10	40%	11	44%	4	16%
17 UAE global economic leadership and competitiveness are intrinsically linked to a robust science and technology innovation pipeline and workforce.					8	32%	11	44%	6	24%
18 Energy authorities or Industrial sector in the UAE regularly support and provide workshops for schools to build STEM awareness and advocacy.			1	4%	12	48%	9	36%	3	12%

19 Energy authorities or Industrial sector in the UAE regularly support and motivate the students for preparation for STEM careers.			1	4%	15	60%	7	28%	2	8%
20 Energy authorities or Industrial sector in the UAE play a significant role in the reforms of STEM educations in schools.			2	8%	15	60%	7	28%	1	4%
21 Schools in the UAE needs efforts, time and resources to cultivate relationships with the Energy authorities or Industrial sector in the UAE.			1	4%			8	32%	16	64%
22 The UAE STEM industries and communities need to communicate more effectively with all of today's students about a range of issues including job opportunities and the fact that they are wanted and needed in these jobs.					1	4%	6	24%	18	72%
Overall Total	17		19		123		153		113	
Total of all the responses	425									
Percentage of the stakeholders' responses	4%		4%		29%		36%		27%	

Table 4: Overview of stakeholders' responses to items regarding STEM education

Table 5 summarizes the responses given by the stakeholders regarding STEM education including awareness, preparing STEM lesson plans and activities, PBL, STEM PDs, CTE education, Energy authorities or Industrial sectors initiatives for STEM, resources for school to cultivate relationship with STEM authorities and the necessity for STEM industrial to expose the students for STEM future careers. About 56% of the stakeholders believe that a problem-based and project-based approaches to STEM curriculums help students to think critically and that Energy authorities or Industrial sector in the UAE involved with STEM education in the UAE. Only 28% of the stakeholders strongly agreed that STEM education had been introduced in the UAE. 40% of the stakeholders are not involved in the operation of preparing STEM lessons and hands-on activities. In the other hand, a total of 88% of the stakeholders between agreeing and strongly agreed that hands-on and minds-on approaches to STEM education is the best way for students to learn science and build crucial science literacy skills, such as critical thinking, problem-solving and the ability to work in teams. Despite, 46% disagreed that PD opportunities around STEM regularly are provided to educators and students in the UAE. Regarding CTE education and the UAE economic linked to science and technology, only 44%

of the stakeholders agreed. Finally, less than a quarter of the responses strongly agreed that the UAE Energy authorities and industrial economic are involved within awareness campaigns to schools, STEM education reforms and students' motivation to STEM careers. Consequently, the responses of the items 21 and 22 revealed that there is insistence for cooperation between the schools and the energy authorities and industrial sectors to promote the STEM education and prepare for the STEM workforce pipeline (see figure 13 and 14).

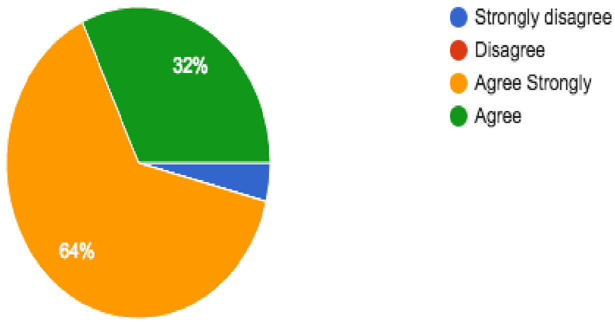

Figure 13: Stakeholders' responses to item 21

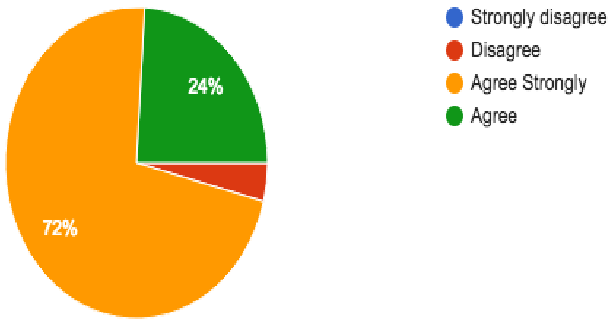

Figure 14: Stakeholders' responses to item 22

3.2.3 Test of significant differences

What are the best practices of STEM?			
Question	**Mean**	**Std. Deviation**	**Test Statistics Interpretation**
Students:			
Gender	Male = 2.13	0.44	**Independent T-test** T = -0.826 P-value = 0.411
	Female = 2.21	0.38	
Grade	G 10 = 2.32	0.34	**Own-way ANOVA** F= 6.225 P-value = 0.003
	G 11 =2.00	0.40	
	G 12 = 2.24	0.47	
Stakeholder:			
Gender	Male = 3.75	0.60	**Independent T-test** T = -0.216 P-value = 0.831
	Female = 3.79	0.50	
Role	Head of Department = 3.73	0.53	**Own-way ANOVA** F= 1.875 P-value = 0.165
	Educator = 4.04	0.42	
	Engineer/Trainer in STEM institute = 3.45	0.64	
	Engineer/trainer/Employee in Energy authorities or Industrial sector in the UAE = 3.48	0.58	
Satisfying	Satisfied = 3.60	0.45	**Independent T-test**

	Not satisfied = 3.82	0.55	T = -0.801 P-value = 0.431
Motivating	Motivated = 3.88	0.49	**Independent T-test** T = 0.499 P-value = 0.623
	Not motivated = 3.75	0.55	
Engaging	Engaged = 3.60	0.42	**Independent T-test** T = -0.468 P-value = 0.644

Table 5: Test of the significant difference -STEM Best Practices

Considering the demographic information, analyzing the students and the stakeholders' responses to the items related to the best practices of STEM (see table 5) and then comparing the Alpha (0.05) with P-value (to ensure that there is no significant difference the P-value must be greater than Alpha) the Independent T-tests and Own-way ANOVA revealed that there were no significant differences between different genders into the perceptions and practices of STEM. All the values were close to zero which means that the majority of the participant have similar responses regarding STEM practices. Except for the students' grades there was a significant difference. As per to Tukey HSD: Grade 10 > Grade 12-Grade 11 (see appendix 6). The T-test and Own-way ANOVA tests for the all the items related to perception and possible STEM model reported that there is no significant difference except for the grades as well as (see tables 6 and 7).

What are the stakeholders' perceptions of STEM practices?				
Question	**Mean**	**Std. Deviation**	**Test Statistics**	**Interpretation**
Students:				
Gender	Male = 2.25	0.48	**Independent T-test** T = -1.245 P-value = 0.216	
	Female = 2.36	0.31		
Grade	G 10 = 2.49	0.36	F= 8.663	**Own-way ANOVA** P-value = 0.000
	G 11 =2.10	0.41		
	G 12 = 2.38	0.43		
Stakeholder:				
Gender	Male = 3.93	0.44	**Independent T-test** T = 0.355 P-value = 0.726	
	Female = 3.87	0.35		
Role	Head of Department = 3.92	0.34	**Own-way ANOVA** F= 0.250 P-value = 0.860	
	Educator = 3.96	0.30		
	Engineer/Trainer in STEM institute = 3.89	0.63		
	Engineer/trainer/Employee in Energy authorities or Industrial sector in the UAE = 3.78	0.55		

Satisfying	Satisfied = 3.71	0.42	**Independent T-test** T = -1.221 P-value = 0.235
	Not satisfied = 3.94	0.37	
Motivating	Motivated = 3.96	0.31	**Independent T-test** T = 0.367 P-value = 0.717
	Not motivated = 3.88	0.41	
Engaging	Engaged = 3.72	0.55	**Independent T-test** T = -0.662 P-value = 0.514

Table 6: Test of the significant difference -Stakeholders Perception

What is a suitable or appropriate STEM education Model for K-12 UAE?				
Question	**Mean**	**Std. Deviation**	**Test Statistics**	**Interpretation**
Students:				
Gender	Male = 2.15	0.45	**Independent T-test** T = -1.267 P-value = 0.209	Form the analysis we can conclude that there is no significant different between students' gender into STEM model.
	Female = 2.28	0.40		
Grade	G 10 = 3.37	0.35	**Own-way ANOVA** F= 6.903 P-value = 0.002	Form the analysis we can conclude that there is significant different between students' grade into STEM model. And we can order by Tukey HSD as follow: G10 = G 12 > G 11
	G 11 = 2.02	0.41		
	G 12 = 2.20	0.49		
Stakeholder:				
Gender	Male = 3.77	0.63	**Independent T-test** T = -0.012 P-value = 0.990	Form the analysis we can conclude that there is no significant different between stakeholders' gender into STEM model.
	Female = 3.77	0.47		
Role	Head of Department = 3.64	0.53	**Own-way ANOVA** F= 1.781 P-value = 0.182	Form the analysis we can conclude that there is no significant difference between stakeholders' role in the STEM model.
	Educator = 4.05	0.37		
	Engineer/Trainer in STEM institute = 3.54	0.65		
	Engineer/trainer/Employee in Energy authorities or Industrial sector in the UAE = 3.51	0.65		
Satisfying	Satisfied = 3.63	0.49	**Independent T-test** T = -0.615 P-value = 0.545	Form the analysis we can conclude that there is no significant different between stakeholders'
	Not satisfied = 3.80	0.55		

				satisfying into STEM model.
Motivating	Motivated = 3.85	0.52	**Independent T-test** T = 0.382 P-value = 0.706	Form the analysis we can conclude that there is no significant different between stakeholders' motivation into STEM model.
	Not motivated = 3.75	0.55		
Engaging	Engaged = 3.63	0.53	**Independent T-test** T = -0.383 P-value = 0.705	Form the analysis we can conclude that there is no significant different between stakeholders' engaging into STEM model.
	Not engaged = 0.78	0.55		

Table 7: Test of the significant difference-Suitable Model of STEM

The main quantitative results highlighted above reflected the students' and the stakeholders' perceptions regarding the STEM best practices. The significant finding regarding the perceptions the appropriate STEM education Model will be discussed and compared with a comparison to the literature review presentation of best practices in chapter five, which will include the discussion, conclusion, recommendation and limitations of the current study.

CHAPTER FIVE

DISCUSSION, CONCLUSION, RECOMMENDATION AND LIMITATIONS

The previous chapter indicated several findings. This chapter interprets the finding, presents the conclusion, list the recommendation and study the limitations for further research to bridge the niche in this area.

4.1 Discussion

Three major concepts revealed from the quantitative results will be discussed. These concepts are the students' perceptions of STEM practices and the stakeholders' perceptions of STEM practice and the appropriate STEM model that can be proposed by comparing the findings with the literature review.

Students' responses revealed important perceptions regarding STEM education practices which can be used to propose an appropriate model for STEM education in the UAE. Most students expressed that STEM education was introduced in the school, while the responses for the availability of STEM lab in the school were different. Only one-third of the students indicated that the STEM practices implemented in the school which indicates several facts; the STEM practices are not embedded consistently. Marshall and Harron (2018) asserted that the making skills or PBL in STEM education is recommended to be an integral part of the school curriculum as it boosts the economic future workforce skills. In addition, stakeholders are not implementing STEM education practices and have a shortage of providing support to educational sectors. Factors like PDs, teacher's efficacy and classroom resources, STEM industries workshops and universities programs affect the execution of STEM education in schools. Similarly, from the literature review the collaboration of the stakeholders in the various communities around the country will be effective to support the STEM educational reforms in schools (Breiner et al., 2012). Furthermore, it has been indicated that stakeholders from Industry or any STEM community ought to improve the awareness about STEM engagement, resources and careers to sustain STEM education and prepare the students to success in STEM colleges and career (Sondergeld, Johnson and Walten, 2016). Thus, understanding the STEM stakeholders' beliefs about teaching practices is significant as the beliefs and perceptions are linked to practices and important to educational reforms and it was important to investigate the stakeholder's willingness to innovate in STEM education (Pryor, Pryor and Kang, 2016).

The results of students' questionnaire demonstrated that only 15.9 % of the students of high school involved STEM campuses and 28.4 attended STEM workshops by STEM industries in the UAE. Workshops and extracurricular activities by STEM stakeholders are practices for inducing STEM awareness between the students especially if the students are involved in vocational conferences and discuss STEM careers with professionals who interact with student and expose them to STEM career activities (Bouvier and Connors 2011). From the stakeholders' questionnaire, the responses for the urgent need for the cooperation between STEM stakeholders like Energy authorities and industrial sectors with schools, educators and students has become a necessity to reform STEM practices. Watters and Diezmann (2013) mentioned that the cooperation between professionals in the local industries and educators increases the teacher professional capacity and sustain the schools and students' engagements in authentic STEM practices. As described by Vygotsky's' constructivist theory, learners can build conceptual understanding when they are exposed to professional and experiences through cooperative learning (Jacobsen et al. 2009; Palmer 2005). Thus, asserts the importance of CTE or vocational education which foster the practical learning, Park et al. (2015) and DiBiase and McDonald (2015) found that the students benefit from laboratory and practical work. It has been mentioned that the embedding of the CTE in the school system contribute in promoting the STEM education as it focuses on apprenticeship education in a framework of career development and vision to the career pathways (Nkhata, 2013).

Students reported that they are implementing the PBL in group-based and that technology and Computer Science are parts of the STEM programs in school. Despite, the responses to the availability of the Engineering course in the school was 34.1%. Integrating the engineering and modelling activities in education is recommended to motivate the hands-on activities and skills. Thus, the MEAs Framework supports the cumulative experimental learning for STEM education by refining and expanding the integration of science, technology and engineering for the applied mathematics skills. Gradually by applying the MEAs instruction the learners improve the metacognition of learners that promote the higher order thinking and the application of the knowledge (Lubis, Pulungan and Fauzi, 2017). Furthermore, 88% of the

Stakeholders current results between agree and strongly agree that best way for students to learn science and build crucial science literacy skills, such as critical thinking, problem-solving and the ability to work in teams is the hands-on activities. The enhancement activities include the PBL and hands-on activities, community ambassador visits, summer camps organized by schools and mentoring programs. The STEM activities grant the students preferable attitude to STEM disciplines, enhance their attainments in the international tests and increase the desirability to join STEM faculties in higher education and continue to STEM careers (Matherly, Amin and Al Nahyan, 2017).

More results from students' responses suggest that 28.4% of the students were consulting business or energy authorities for their STEM project. This is aligned with the results published by (Mahil, 2016) who reflected that the industrial sectors and energies authorities in the UAE have initiatives for encouraging the students for STEM fields like providing scholarships, launching competitions and providing workshops for school. The cooperation between educational sectors and UAE governmental authorities and private industries increases the student's motivation toward STEM fields. However, 16% of the responses from the stakeholders' questionnaire reported that Energy authorities or Industrial sector in the UAE involved with STEM education in your city or school. This disadvantage should be avoided in order to develop STEM education and practices, considering that Johnson (2012) proved that stakeholders' appetite to implement reforms, flexibility and motivations for students all affect the engagements to perform the STEM education.

According to the stakeholders' responses, 64% disagreed that the PDs around STEM were regularly provided to educators or students in the UAE noting that 44% of the stakeholders are educators. In addition, from the students' questionnaire the responses of attending STEM workshops were 28%. Valenzuela (2018) asserted that in the US the ITEEA is providing PDs and workshops for educators and students to foster the technology and engineering skills in learning and implement the STEM disciplines interconnectedness.

Furthermore, based on the stakeholders' responses 60% of them between agree and strongly agree to revise the curriculum with the team and implement the STEM skills integration. The revision and modification of the STEM curriculum to be synchronized in the skills and content will help in implementing the STEM integration. Chalmers et al. (2018) asserted that to widen the students' conceptual thinking, the knowledge from various STEM disciplines perspective should be provided to the students. Thus, according to McFadden and Roehrig (2017) the collaboration between educators is required during the curriculum design and integration.

Some of the STEM practices were implemented poorly in the school, this can be caused by the stakeholders' support to implement the STEM practices that requires more efforts when organizing PDs for training the educators, workshops and campuses for the students and preparing the integrated STEM curriculum. That was supported by Vennix, Brok and Taconis (2016) that to comprehensive implementation of the CTE and STEM in the educational systems, the educators and students ought to collaborate with institutions and external companies to understand the real-life contexts and prepare the students to illuminate their sights for the future careers. From the stakeholder's questionnaire the results revealed that the educators who form 44% of the participant have a positive interpretation regarding the collaboration in out of school training but that require time and resources. Similarly, Gourgey, Asiabanpour and Fenimore (2011) asserted that educators require more time to prepare for STEM lesson and Bell (2015) indicated that STEM educators ought to be in an ongoing meeting to integrate STEM disciplines. As an instant of PDs in the UAE, Blaik Hourani and Litz (2018) mentioned that ADEC in the city of Abu Dhabi has the program. Tamkeen for educators and leaders' PDs that aims to improve Abu Dhabi schools.

There were no significant differences between students' gender responses to STEM, perception, practices or STEM proposed model. Although, it has been indicated that the demographic influences like gender has significant differences. For example, in a study held by Crisp, Nora and Taggart (2009) mentioned that female's tendency to join STEM fields in colleges are less than males, although the females have higher school attainment, the males proved higher skills is STEM careers (Bernasconi, 2017).

In addition, 52% of the students had the tendency to join STEM faculties which assert the importance of promoting the STEM skills in school to prepare the students for STEM faculties. Referring to the literature review, Becker and Kyungsuk (2011) mentioned that the implementation of STEM education in school stages has positive impacts students 21st learning skills and toward STEM fields in postsecondary.

The results of the study indicated that the students and stakeholders have well conscious regarding the significance of STEM education for the 21st-century workforce. On the other hand, the implementation of STEM practices is not common and require further arrangements, clarification of implementation and funding for the resources. The stakeholders and especially the decision makers in the educational governments, energy authorities have to issue an obvious procedure for the schools to proceed in the implementation as well as fund the resources of STEM education. Correspondingly, Assefa and Rorissa (2013) indicated that the NSF appeals for US government's, institution and agencies for the intervention to support and reform the STEM education.

The third research question of this study was whether a suitable or appropriate model of STEM education for K-12 in the UAE could be proposed. Based on the literature review and the results of the data analysis of this study, figure 15 is a proposal for the procedure of the STEM education model. This proposed model can be issued by the educational governments to guide the educational sectors for the aspects that ought to be followed to achieve the comprehensive STEM education in their institution.

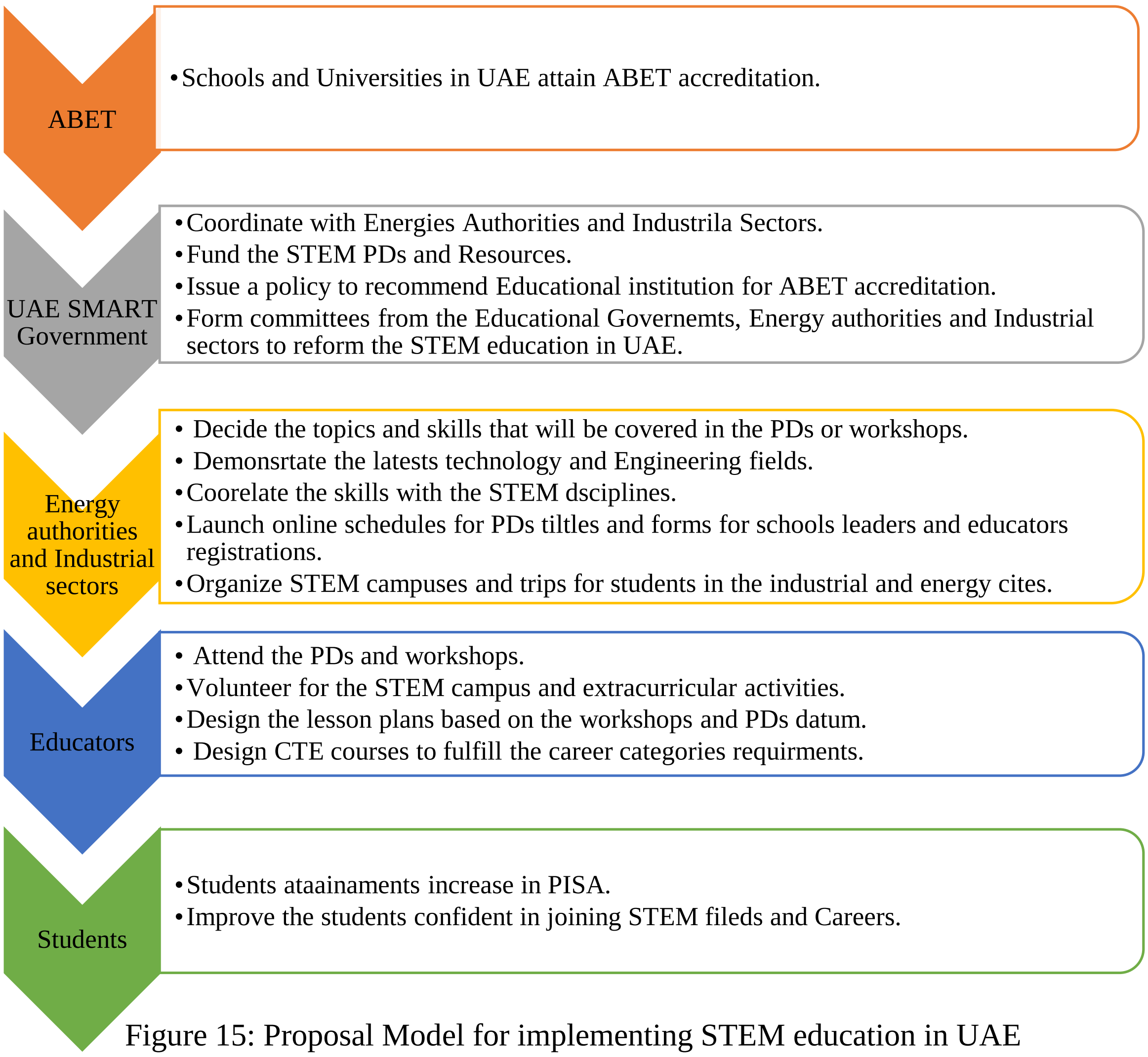

Figure 15: Proposal Model for implementing STEM education in UAE

4.2 Conclusion

This research study investigated the stakeholders and students' perceptions of STEM practices in the UAE. The stakeholder responses regarding STEM practices confirmed that the implementation requires further clarification, guidance, collaboration and support. Furthermore, educators require time to collaborate and attend PDs and workshops and get the training and supports. Coordination between the UAE government, energy authorities and educational institution will promote the STEM education implementation. That will illustrate the implementation for the educators and students and will add value to the significant of STEM education.

The finding as well presents best practices of STEM education that are not comprehensively implemented such as PDs, workshops, STEM campuses, extracurricular activities, STEM Labs, CTE courses and energy and industrial sectors interventions to reform STEM education.

Finally, the proposed model for STEM education was demonstrated to sum up the procedure to fulfil the best practices of STEM and achieve the intended results for the UAE future workforce and knowledge-based economy.

4.3 Recommendation

This study suggests a model for implementing STEM education in the UAE, consequently for further studies that will investigate similar field it is recommended to collect and analyse the data from different schools' curriculum and cities in the UAE. Moreover, to implement a study that covers the classroom implementation of STEM, measures the collaboration and coordination between stakeholder and the socioeconomic status (SES) into demographic variables.

4.4 Limitations

Firstly, the questionnaires do not contain questions about how the educators are integrating the content of the STEM discipline as that could assist in understanding the practice of planning for integration. Secondly, this study has investigated the stakeholder's perceptions in the UAE through two surveys for students and stakeholders, data fusion technique for data should have been used to integrate the data from the two questionnaires and produce one combined result rather than two separate results (Gil-Izquierdo and Cordero, 2018).

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Appendices

Appendix 1

Number	CTE Career Group	Brief description
1	Agriculture, food, and natural resources	Prepare the students for jobs in agriculture and development of food production and natural resources including training, education and resources management.
2	Architecture and construction	Students are educated for practical skills for diverse architecture and construction programs.
3	Arts, A/V Technology, and Communications	Students learn the skills of designing and performing multimedia content, visual, journalism and entertainments.
4	Business, management, and administration	Present the aspects of accounting, productive business operation, marketing and finance to the students.
5	Education and training	Grant the learners the skills and identify the careers and services related to education and training such as classroom teachers, community class leader, consular, librarian, principal or sports or activity coach.
6	Finance	Educate the students for financial careers and services such as financial management, banking, insurance and investment planning.
7	Government and public administration	Prepare the students for seven career pathways which include the foreign, governance, public management, security, taxation, planning and regulations.
8	Health science	Prepare the students for careers that boost health informatics and services, diagnosis development and biotechnology research and development.
9	Hospitality and tourism	Introduces students to restaurants and food services operations, management and marketing. As well as, organizing the travel and tourism processes.
10	Human services	Sponsor the student's readiness for careers of community and consumer services and organizing of human needs.
11	Information technology	Educate the students for the information technology skills including hardware and software planning, design

		development and support, services of systems integration and multimedia specialists' fields.
12	Law, public safety, corrections, and security	Train and educate the students for homeland security and public safety. For example, to handle the responsibilities of defending citizens from crimes and protecting them from harms and natural disasters.
13	Manufacturing	Train the students for managing processes of material to the final products, engineering and technical process, maintenance and repair.
14	Marketing, sales, and service	Teaching the skills of buying, merchandising, promotions and electronic marketing.
15	Science, technology, engineering, and mathematics	Uses the student's abilities and interest to prepare them for STEM careers such as social sciences, engineering, laboratories services.
16	Transportation, distribution, and logistics	Students pursue training in transpiration management, logistics operations and equipment's maintenance.

Appendix 2

The 4ps model for STEM implementation action plan (Bybee, 2013).

Perspectives	What is the risk for school systems?	How much will it cost school systems in the financial term?	What are the constraints against reforms for school systems?	Who has the responsibilities for reforms at the state and school levels?	What are the benefits for schools and students?
Purpose • State the reform goals.					

• Define the priorities that should be established for the goals.					
Policy • Decide design criteria. • Define the instruction criteria. • Develop framework for the curriculum and instruction.					
Program • Develop materials or adopting a program and implement them.					
Practices • Change teaching strategies. • Differentiate the materials to the					

individual needs.					

Appendix 3

Survey for Secondary School Students Survey

Is the science, technology, engineering, and mathematics (STEM) education movement reaching you? If so, how is it affecting your learning? Take a few minutes to let us know your thoughts by taking this survey on STEM education. Your participation in this survey is voluntary and anonymous.

Demographic information

1. **Are you a boy or a girl?**
   ____Boy
   ____Girl

2. **What grade are you in? ____________**

STEM for students

3. **Has STEM education (e.g. programs, courses or certification) been introduced in your school?**
   Yes
   No
   I don’t know
   Briefly describe how.

4. **If you have a STEM class or course in your school, what percentage are the following disciplines/areas part of that class/course (needs to add up to 100%)**
   Science _________
   Technology______
   Engineering______
   Mathematics______

5. **Do you have new science and mathematics requirements or courses (Elective Courses-New Resources/Materials/Tools)?**
   Yes
   No
   I don’t know
   If so, what are they?

6. **Does your school offer engineering courses or projects?**
   Yes

No
I don’t know
If so, what are they?

7. **Is there more time for teaching science at your school as a result of STEM?**
Yes
No
I don’t know
Why or why not?

8. **Is there a dedicated STEM lab at your school?**
Yes
No
I don’t know

9. **Have you been in STEM camps/clubs such as environmental, sustainability or machine learning camps or clubs in the school?**
Yes
No
I don’t know
If so, what are they?

10. **Is technology used throughout your STEM program as a tool to facilitate research, investigation and design?**
Yes
No
I don’t know

11. **Is computer science considered part of the STEM education in your school?**
Yes
No
I don’t know

12. **Do you have teachers in your school who are certified in STEM?**
Yes
No
I don’t know

13. **Are workshop opportunities around STEM regularly provided to students in your school by STEM agencies (Energy/Investment/Companies authorities)?**
Yes
No
I don’t know

14. **Are STEM students regularly challenged by complex problems related to real-world scenarios?**
Yes
No
I don’t know

15. Is your STEM fair project an individual project or a group project?
Individual
Group

16. **How would you describe the assistance, if any, you received from teachers at your school as you prepared for your STEM project?**
None
Very Little
Quite a bit
A lot

17. Did you consult with any local businesses/authorities, or individuals from businesses to help you prepare your STEM project?
Yes
No

18. Are you planning to major and considering a career in math, science, technology, or engineering in college?
Yes
No
I don't know

19. Apply what we are learning to our daily life.
Agree a lot
Not sure
Disagree

20. **Talk about the types of jobs and careers that use STEM.**
Agree a lot
Not sure
Disagree

21. **Are you interested in the following? (**Check all that apply**)**
- ☐ Hanging out for a few hours with an employee at his or her workplace.
- ☐ Touring a local employer.
- ☐ Participating in an internship one or more days a week at an area employer.
- ☐ Earning high school credit for learning a trade at a company.
- ☐ More information about salaries in high-tech jobs.
- ☐ Finding out more about jobs in math, science and technical fields.
- ☐ Pursuing an in-depth career-oriented project.

22. **After high school I plan to go to:**
- o Four-year college
- o Two-year college
- o Technical, business or trade school
- o Apprenticeship
- o Find a full-time job
- o Don't know
- o Other.

Appendix 4

Teachers, HODs, Principals and STEM partnership (Energy authorities and the Industrial sector in UAE) Survey

Is the science, technology, engineering, and mathematics (STEM) education movement reaching you? If so, how is it affecting your education methods and instructions? Take a few minutes to let us know your thoughts by taking this survey on STEM education and initiatives to reform STEM education. Your participation on this survey is voluntary and anonymous.

Demographic information

1. **Are you a male or a female?**

____male
____female

2. **What is your professional role?**

School Principal
Head of Department
Educator
Engineer/Trainer in STEM institute

Engineer/trainer/Employee in Energy authorities or Industrial sector in UAE

3. **Are you satisfied with your job?**

Yes
No

4. **Are you getting motivated by your job?**

Yes
No

5. **Are you engaged in your job?**

Yes
No

STEM stakeholders (HODs-Principals- Energy authorities or Industrial sector in UAE).

6. **The STEM education (e.g. programs, courses, certification or workshops) has been introduced in your institution, school or city.**

Strongly disagree
Disagree
Agree Strongly

Agree

If agree or agree strongly, briefly describe how?

7. **I enjoy preparing lessons plans, teaching and preparing activities on a team with educators of STEM disciplines.**

Strongly disagree
Disagree
Agree Strongly
Agree

Not applicable

8. **I am comfortable using a problem-based and project-based approaches in education in my work.**

Strongly disagree
Disagree
Agree Strongly
Agree
Not applicable

9. **A hands-on and minds-on approaches to STEM education is the best way for students to learn science and build crucial science literacy skills, such as critical thinking, problem-solving and the ability to work in teams.**

Strongly disagree
Disagree
Agree Strongly
Agree

10. **I enjoy revising the STEM curriculum on a team with other teachers and modifying it to be integrated and content synchronized regardless the skills will be taught in each discipline.**

Strongly disagree
Disagree
Agree Strongly
Agree

11. **I believe that a problem-based and project-based approaches to STEM curriculums can lead to students missing the learning of important basic facts.**

Strongly disagree
Disagree
Agree Strongly
Agree

12. **I believe that a problem-based and project-based approaches to STEM curriculums help students to think critically.**
Strongly disagree
Disagree
Agree Strongly
Agree

13. **Energy authorities or Industrial sector in UAE involved with STEM education in your city or school.**
Strongly disagree
Disagree
Agree Strongly
Agree

14. **The STEM curriculum in your city/school is multidisciplinary and it includes lessons that are integrated (to include math, science, technology, and engineering,).**
Strongly disagree
Disagree
Agree Strongly
Agree

15. **Professional development opportunities around STEM regularly provided to educators and students in your city or school.**
Strongly disagree
Disagree
Agree Strongly
Agree

16. **Students in your city/school regularly involved with math, science, engineering or career and technical education (CTE) competitions.**
Strongly disagree
Disagree
Agree Strongly
Agree

17. **UAE global economic leadership and competitiveness are intrinsically linked to a robust science and technology innovation pipeline and workforce.**
Strongly disagree
Disagree
Agree Strongly
Agree

18. **Energy authorities or Industrial sector in UAE regularly support and provide workshops for schools to build STEM awareness and advocacy.**
Strongly disagree
Disagree
Agree Strongly
Agree

19. **Energy authorities or Industrial sector in UAE regularly support and motivate the students for preparation for STEM careers.**
    Strongly disagree
    Disagree
    Agree Strongly
    Agree
    If agree or agree strongly, briefly describe how?

20. **Energy authorities or Industrial sector in UAE play a significant role in the reforms of STEM educations in schools.**
    Strongly disagree
    Disagree
    Agree Strongly
    Agree
    If agree or agree strongly, briefly describe how?

21. **Schools in UAE needs efforts, time and resources to cultivate relationships with the Energy authorities or Industrial sector in UAE.**
    Strongly disagree

    Disagree
    Agree Strongly
    Agree

22. UAEs' STEM industries and communities need to more effectively communicate with all of today's students about a range of issues including job opportunities and the fact that they are wanted and needed in these jobs.

Strongly disagree

Disagree
Agree Strongly
Agree

Appendix 5

The British University in Dubai

www.buid.ac.ae

5/14/2018

This is to certify that Ms.Sawsan Malaka with Student ID number 2015101098 is a registered part-time student in the Master of Education offered by The British University in Dubai since September 2015.

Ms. Malaka is currently collecting data for her research (Investigate the Stakeholder's perception of best practices of STEM Education).

She is required to gather data to investigate the implementation of STEM education and to attend STEM lessons in high schools that will help her in writing the final research. Your permission to conduct her research in your organisation is hereby requested. Further support provided to her in this regard will be highly appreciated.

Any information given will be used solely for academic purposes.

This letter is issued on Ms.Malaka's request.

Yours sincerely,

Dr. Amer Alaya

Head of Academic and Student Administration

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Appendix 6

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Grade	(J) Grade	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Practices	10	11	.32510*	.09648	.003	.0950	.5552
		12	.08046	.11931	.779	-.2042	.3651
	11	10	-.32510*	.09648	.003	-.5552	-.0950
		12	-.24464	.11243	.081	-.5128	.0236
	12	10	-.08046	.11931	.779	-.3651	.2042
		11	.24464	.11243	.081	-.0236	.5128
Perceptions	10	11	.38316*	.09564	.000	.1550	.6113
		12	.10673	.11827	.640	-.1754	.3889
	11	10	-.38316*	.09564	.000	-.6113	-.1550
		12	-.27642*	.11145	.040	-.5423	-.0106
	12	10	-.10673	.11827	.640	-.3889	.1754
		11	.27642*	.11145	.040	.0106	.5423
Model	10	11	.34238*	.09904	.002	.1061	.5786
		12	.05364	.12248	.900	-.2385	.3458
	11	10	-.34238*	.09904	.002	-.5786	-.1061
		12	-.28874*	.11541	.038	-.5640	-.0134
	12	10	-.05364	.12248	.900	-.3458	.2385
		11	.28874*	.11541	.038	.0134	.5640

*. The mean difference is significant at the 0.05 level.