

**Development of Entrepreneurial Core Competencies:
E-STEM Model Implementation for High School Students
in the UAE**

تطوير الكفاءات الأساسية لريادة الأعمال: تنفيذ نموذج "أي-ستيم" مع طلاب
المدارس الثانوية في دولة الإمارات العربية المتحدة

by

MARWA ELTANAHY

**A thesis submitted in partial fulfilment
of the requirements for the degree of
DOCTOR OF PHILOSOPHY IN EDUCATION
at
The British University in Dubai**

September 2019

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البريطانية في
دبي



The
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Thesis Supervisor
Professor Sufian Forawi

Approved for award:

Dr. Nasser Mansour
External Examiner

Professor Aymen Masadeh
Chair of Examiners

Dr. Tendai Charles
Internal Examiner

Professor Abdullah Alshamsi
Chair of Research Degree Committee

Date: 30 October 2019

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Abstract

STEM education has been emphasized in the UAE education reform because science, technology, mathematics and engineering are considered as the main disciplines that reflect the development of a country's economic situation. For more effective STEM implementation in its early stage in the UAE, there is a need for an integrated framework to guide STEM educators. The literature recommended restructuring STEM education to accommodate entrepreneurial practices because STEM professions are not desirable for everyone and STEM designs could be easily lost unless they involve a basic understanding of the market. However, the existing STEM literature has not succeeded in providing any model that infuses entrepreneurial activities into STEM education. Accordingly, the purpose of the present study is six-fold (1) to explore educational leaders' views about incorporating entrepreneurial practices into STEM education, (2) to investigate the effective entrepreneurial practices within STEM classes that enhance incorporating entrepreneurial practices into STEM education as well as the challenges of successful incorporation, (3) to investigate participating teachers' demographics variables in relation to incorporating entrepreneurial practices into STEM education, (4) to develop a model of an entrepreneurial-STEM education (E-STEM), (5) to explore E-STEM teachers' beliefs regarding the impact of implementing an E-STEM model on students' learning outcomes and (6) to examine the effect of E-STEM practices on students' entrepreneurial competencies. Guided by the perspectives of Vygotsky's social constructivist theory, Lava's situated cognition theory, Jacob's interdisciplinary theory, entrepreneurship intentions model, Hilgard's motivational theory and the theoretical model of scientific competencies. The E-STEM model was developed and examined in the UAE context through a multiphase-mixed method to fulfil the multi-fold purpose of the study in two sequential stages. The study provides an E-STEM model to explain how entrepreneurial practices could be integrated with existing STEM curriculum. Many important results were revealed 1) High School STEM teachers believed in the possibility of incorporating entrepreneurial practices into STEM education in the UAE through integrating business practices 2) The E-STEM model enhances a student-competency profile including entrepreneurial knowledge, skills and attitudes 3) being an entrepreneur becomes a new learning disposition in high school as a highlighted impact of E-STEM implementation on students' learning outcomes. In this regard, the application of E-STEM model provided an evidence-based recommendation to guide policy makers and curriculum developers to restructure STEM education to accommodate effective entrepreneurial practices in order to enhance students' entrepreneurial competencies.

Key Words: STEM education- Entrepreneurial Learning – Entrepreneurship Education – Entrepreneurial Competencies – Interdisciplinary approach

الخلاصة

لقد تم التأكيد على تعليم "ستيم" في الإمارات العربية المتحدة من أجل إصلاح التعليم بشكل عام لأن مواد العلوم والتكنولوجيا والرياضيات والهندسة تعتبر من التخصصات الرئيسية التي تعكس تطور الوضع الاقتصادي في البلدان. ولتنفيذ تعليم "ستيم" بأكثر فاعلية في مرحلته المبكرة في الإمارات العربية المتحدة، هناك حاجة لبناء إطار متكامل لتوجيه معلمي "ستيم". ولقد أوصت الأدبيات بإعادة هيكلة تعليم "ستيم" لاستيعاب ممارسات الريادة لأن مهن "ستيم" ليست مرغوبة للجميع، ويمكن بسهولة فقدان تصميمات "ستيم" ما لم تتضمن فهما أساسيا لاحتياجات السوق. ومع ذلك لم تنجح أدبيات "ستيم" حتى الآن في تقديم أي نموذج يدمج أنشطة تنظيم المشاريع في تعليم "ستيم". وفقا لذلك فإن الغرض من هذه الدراسة يشمل ستة أهداف (١) استكشاف وجهات نظر القادة التربويين حول دمج ممارسات الريادة في تعليم "ستيم". (٢) للتحقق من ممارسات الريادة الفعالة داخل فصول "ستيم" والتي تتعزز الدمج بين ممارسات الريادة وتعليم "ستيم" (٣) للتحقق من علاقة عوامل التركيبة السكانية للمعلمين المشاركين فيما يتعلق بإدراج ممارسات ريادة الأعمال في تعليم "ستيم" (٤) لتطوير نموذج لدمج ممارسات الريادة بتعليم "ستيم" يسمى "E-STEM" أو "اي-ستيم" (٥) لاستكشاف معتقدات معلمي "أي-ستيم" فيما يتعلق بتأثير تطبيق هذا النموذج على نواتج تعلم الطلاب (٦) لدراسة تأثير ممارسات "أي-ستيم" على الكفاءات الريادية للطلاب. استرشادا بتصور نظرية البناء الاجتماعي لـ "Vygotsky"، ونظرية الإدراج لـ "Lava"، ونظرية تعدد التخصصات لـ "Jacob"، ونموذج "Ajzen" لريادة الأعمال ونظرية "Hilgard" التحفيزية، الي جانب النموذج النظري للكفاءات العلمية، تم تطوير نموذج "أي-ستيم" ودرسته في سياق دولة الإمارات العربية المتحدة من خلال طريقة الخلط متعددة المراحل لتحقيق غرض البحث متعدد الأهداف وذلك في مرحلتين متتاليتين. وبالتالي لقد قدمت هذه الدراسة نموذج "أي-ستيم" الذي يشرح كيفية دمج ممارسات الريادة مع منهاج "ستيم" الموجودة فعليا. ولقد كشفت الدراسة العديد من النتائج المهمة (١) يعتقد معلمي "ستيم" في المدارس الثانوية في دولة الإمارات بإمكانية دمج ممارسات الريادة مع تعليم "ستيم" لذلك بدمج الممارسات التجارية (٢) يعزز نموذج "أي-ستيم" الكفاءات الريادية للطلاب والتي تشمل معارفهم ومهاراتهم وميولهم لتنظيم المشاريع المتعلقة بـ "ستيم" (٣) كونك رائد أعمال أصبح تصرفا تعليميا جديدا في المدرسة وهذا يعتبر تأثير بارز لنموذج "أي-ستيم" على نواتج تعلم الطلاب. وبهذا فقط تم تطوير نموذج "أي-ستيم" وفحصه في هذه الدراسة لتقديم توصية مبنية على الأدلة لتوجيه صناع السياسات ومطوري المناهج الدراسية لإعادة هيكلة تعليم "ستيم" لاستيعاب ممارسات تنظيم المشاريع الفعالة من أجل تعزيز كفاءات الطلاب في مجال الريادة في دولة الإمارات العربية المتحدة.

الكلمات والعبارات الرئيسية: تعليم "ستيم"، تعليم الريادية، تعليم ريادة الأعمال، الكفاءات الريادية، منهج متعدد التخصصات،

DEDICATION

I dedicate this thesis to my big family and friends, as an appreciation to their constant love and support, your inspiration and motivational words have carried me throughout this process.

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Lastly, I hope that the insights offered here might drive policies that will advance the good work being done by this research.

Table of Contents

CHAPTER 1: INTRODUCTION	1
1.1 Research Background	6
1.2 Problem Statement	9
1.3 Purpose & Research Questions	12
1.4 Significance of the Research Study	14
1.5 Education Context of the UAE	17
1.6 UAE Initiatives towards Education Reform	19
1.7 STEM and Entrepreneurship in the UAE.....	20
1.8 Overview of the Research Study	22
 CHAPTER 2: THEORETICAL FRAMEWORK AND	
LITERATURE REVIEW	24
2.1 Theoretical Framework	25
2.2.1 Social Constructivist Theory.....	26
2.2.2 Situated Cognition Theory	29
2.2.3 Interdisciplinary Theory.....	31
2.2.4 Theory of Planned Behaviour	33
2.2.5 Trilogy of Success Theory	34
2.2.6 Theoretical Model of Scientific Competencies.....	36
2.2.7 Experiential Learning Theory	37
2.2 Conceptual Framework	41
2.3 Literature Review	50
2.3.1 STEM Education.....	50
2.3.2 STEM Career through Education.....	54
2.3.3 Competencies developed through STEM and entrepreneurial Practices	56
2.3.3.1 Entrepreneurial Knowledge	62
2.3.3.2 Entrepreneurial Skills.....	65
2.3.3.3 Entrepreneurial Attitude.....	71
2.3.4 Entrepreneurship education	75
2.3.5 Teaching approaches of entrepreneurship education	78
2.3.6 The relationship between entrepreneurship and STEM education	83
2.3.7 E-STEM Best Pedagogies.....	85

2.4 Conclusion	93
CHAPTER 3: METHODOLOGY	96
3.1 Research Approach	97
3.2 Research Methods.....	105
3.2.1 Site, Sampling & Participants	107
3.2.2 Data Collection	112
3.2.2.1 Exploratory Sequential Mixed Methods Design	113
Instrumentation of the exploratory stage	118
Semi-Structured Interview	118
STEM Teachers Questionnaire	122
Piloting of STEM Teacher Questionnaire	127
Validity of STEM Teachers Questionnaire	129
Reliability of STEM Teachers Questionnaire	130
3.2.2.2 Convergent Parallel Design.....	132
Instrumentation of the Confirmatory Stage	138
E-STEM Teacher Interviews.....	138
E-STEM Student Questionnaire.....	139
Validity and Reliability of E-STEM Student Questionnaire	141
Validity of E-STEM Student Questionnaire.....	141
Reliability of the E-STEM Students Questionnaire	146
3.3 Data Analysis.....	148
3.3.1 Qualitative Data Analysis	148
3.3.2 Quantitative Data Analysis	154
3.4 Ethical Considerations	156
3.5 Summary	158
CHAPTER 4: DATA ANALYSIS AND RESULTS	159
4.1 Results of the Exploratory Stage.....	160
4.1.1 Results of Educational Leaders Interview	160
4.1.2 Results of STEM Teacher Questionnaire	174
4.1.3 Results of E-STEM Implementation.....	200
4.2 Results of the Confirmatory Stage.....	205
4.2.1 Results of E-STEM Teachers Interview	206
4.2.2 Results of E-STEM Students Questionnaire.....	215
4.2.3 Results of testing E-STEM Model	218

CHAPTER 5: DISCUSSION.....	227
5.1 Pedagogy	228
5.1.1 Pedagogical Strategies of E-STEM Learning	228
5.1.2 E-STEM Learning Environment.....	230
5.1.3 Main Challenges of E-STEM Learning	232
5.1.4 Philosophy of E-STEM Learning	233
5.2 Practice	235
5.2.1 Current Effective Practices of E-STEM Learning	236
5.2.2 Suggested Practices for E-STEM Learning	238
5.2.3 Building Blocks of E-STEM Learning	240
5.3 Outcome.....	241
5.3.1 E-STEM Impact on Students' Learning Outcomes	242
5.3.2 Development of Students' Entrepreneurial Competencies	245
5.3.3 Advantages of E-STEM Learning	249
Chapter 6: CONCLUSION AND RECOMMENDATION.....	251
6.1 Development of E-STEM Model	251
6.1.1 Principles of E-STEM Learning	252
6.1.2 Main Pulleys of Interdisciplinary E-STEM Learning.....	253
6.1.3 Framework of the E-STEM Learning	255
6.1.4 Pre-Implementation Stage of E-STEM.....	256
6.1.5 Situated Platforms of E-STEM Model.....	259
6.2 Conclusion	260
6.3 Implication	264
6.3.1 Practical Implications.....	264
6.3.2 Professional Implications.....	266
6.4 Recommendation	268
6.5 Limitation	269
REFERENCES	271
APPENDICES.....	303

List of Figures

Figure 1: Theoretical Framework of the Study.....	26
Figure 2: Value of Interdisciplinary Approach (Thornburg 2008, p.3).....	32
Figure 3: Overview of the General Model of Scientific Competencies (Dietrich et al. 2015, p.117)	36
Figure 4: Conceptual Framework of the Study.....	42
Figure 5: Integrating Pedagogical Methods to Create New Teaching and Learning Model	44
Figure 6: Key Competencies Adopted in the Current Study	60
Figure 7: The Focus of Entrepreneurship in Different Educational Stages	82
Figure 8: Didactic Triangle to show the Transferred Focus of the Teaching Paradigm.....	86
Figure 9: Stages of the Multiphase Mixed Methods.....	101
Figure 10: Quasi-Experimental Design Plan	111
Figure 11: Stages of the Exploratory Sequential Mixed Methods Design	114
Figure 12: The Matching-Only Pretest-Posttest Control Group Design	136
Figure 13: Stages of the Convergent Parallel Mixed Methods Design.....	137
Figure 14: Strategies Applied to Analyze Qualitative Data.....	150
Figure 15: Actual Example of the Three Levels of Coding Applied in the Study	152
Figure 16: Theoretical Hypothesis of the Quantitative Study.....	155
Figure 17: Demographic Information of the Participating Teachers	176
Figure 18: The Trend of the Entrepreneurial Incorporation into STEM Education in High School	235
Figure 19: The Main Building Blocks of E-STEM Learning	240
Figure 20: The main pulleys of the Interdisciplinary E-STEM Learning	254
Figure 21: The Framework of the Implemented E-STEM Model.....	255
Figure 22: Strategic Plan of the Intended E-STEM Model.....	256

List of Tables

Table 1: Competencies Developed through E-STEM Implementation.....	57
Table 2: Differences between Education for and through Entrepreneurship	80
Table 3: The Main Differences between Experimental and Traditional Learning Instructions.....	88
Table 4: Outline of the Applied Methodology.....	106
Table 5: Fully Anchored Rating Scale Used for each Cluster in the Developed Questionnaire of STEM Teachers	125
Table 6: Cronbach's Alpha Coefficient of the Main Variables of STEM Teachers' Piloting Questionnaire	131
Table 7: Values of Cronbach Alpha Coefficient of the Variables in the Teachers' Questionnaire	132
Table 8: Likert Scale Used for each Cluster in the Developed Questionnaire of E-STEM Students	140
Table 9: Component Matrix of the Dependent Variables of the Study.....	143
Table 10: Results of Factor Analysis	145
Table 11: Cronbach's Alpha Coefficient of the Test-Retest Administration of Students' Questionnaire	146
Table 12: Values of Cronbach's Alpha Coefficient of the Variables in the Students' Questionnaire	147
Table 13: Summary of Leaders' Beliefs about Incorporating Entrepreneurial Practices into STEM Education	173
Table 14: Descending Rate of Current Practices Applied in the STEM Classes to Enhance Entrepreneurial Learning.....	178
Table 15: Descending Rate of Practices Suggested by STEM Teachers to Enhance Entrepreneurial Learning	179
Table 16: Rate of Teachers' Perceptions regarding Effective Practices Applied in STEM Classes based on Demographics.....	180
Table 17: Descending Rate of Obstacles of Incorporating Entrepreneurial Practices into STEM Education ...	183
Table 18: Rate of STEM Teachers' Perceptions regarding Obstacles of Incorporation based on Demographics	184
Table 19: ANOVA Table for the Group Difference by Emirate of Participants	186
Table 20: ANOVA Table for the Group Difference by Gender of Participants	187
Table 21: ANOVA Table for the Group Difference by Academic Qualification of Participants	189
Table 22: Post Hoc Comparison with the Use of Games-Howell Test	190
Table 23: ANOVA Table for the Group Difference by Teaching Experience of Participants.....	192
Table 24: Post Hoc Comparison with the Use of Hochberg Test	193
Table 25: ANOVA Table for the Group Difference by Subject Taught of Participants	195
Table 26: Post Hoc Comparison with the Use of Games-Howell Test	196
Table 27: Outcomes of Integrated E-STEM knowledge - based Designs.....	201
Table 28: Summary of Teachers' Beliefs regarding their E-STEM Model Experience	214
Table 29: T-test Comparison of Pre-tests Scores for both Control and Experimental Groups	217
Table 30: T-test Comparison between Pre & Post-tests of the Total Scores of the Two Groups.....	218
Table 31: T-test Comparison of Post-tests Scores for both Control and Experimental Groups	219
Table 32: Integrated Results from Exploratory and Confirmatory Stages.....	222
Table 33: The Form of the Ability Determination of Individuals.....	257
Table 34: The Form of SWOT Analysis of the Proposed E-STEM Project.....	258
Table 35: Business Plan Form.....	259

CHAPTER 1: INTRODUCTION

Education has always been recognized as the process people undergo to acquire knowledge, enhance abilities, improve attitudes to their interesting fields of study, and develop skills that are necessary for better life in the community. Moreover, education has a great responsibility in preparing pupils for the workplace, as they may become employers (entrepreneurs) or employees (Okeke 2007). The organisation for Economic Cooperation and Development (OECD) (2015) called for enhancing the educational outputs in the United Arab Emirates (UAE) because “the coexistence of high unemployment and skills shortages in much of the Arab world illustrates that producing more of the same graduates cannot be the answer” (p. 3). To achieve the noble purpose of the education reform and produce students who are able to satisfy the workplace requirements, education systems should equip students with the basic tools for national, social and economic development as well as industrialization (Aguele & Agwagah 2007). Further, educational practices should foster the habit of scientific attitudes in learners through multiple effective mental activities that help them improve their imaginative skills and constructive reasoning skills (Ezeudu, Ofoegbu & Anyaegbunnam 2013). Speakers at one of the educational conferences held in Dubai suggested that traditional assessments and school tests should be replaced with more opportunities of experiential learning under the supervision of teachers whom have the ability to enhance students’ motivation to learn (Hanif 2017). In this regard, the urgency to enhance improvement and achievement in education related to science, technology, engineering and mathematics (STEM) becomes evident by the massive reform programs that have given all its focus to STEM disciplines and its applications that should meet the workplace requirements (AAAS 1989, 1993; ABET 2004; ITEA 1996, 2000, 2002, 2007; NCTM 1989, 2000; NRC 1989, 1994, 1996; US Department of Education 2016; Bernstein-Sierra & Kezar 2017; Shaer, Zakzak & Shibl 2019). Thus, the prudent leadership of the UAE focused on the innovation

and highlighted its fundamental role in enhancing UAE economic progress. The innovation was defined as “The aspiration to achieve development by generating creative ideas and introducing new products, services and operations that improve the overall quality of life” (UAE government 2015, p.6). In terms of this emphasis, His Highness Sheikh Mohammed bin Rashid Al Maktoum, UAE Vice President, Prime Minister and Ruler of Dubai established the National Innovation Strategy (NIS) that seeks to recognize the UAE among the world’s most pioneering countries by the Golden Jubilee of the Union (UAE government 2015).

Accordingly, the Science, Technology and Innovation Policy (STIP) was launched in November 2015 (UAE Government, 2015) to emphasize and reflect the purposeful transition towards a knowledge-based economy in the UAE (Farah 2012). Thus, UAE National Agenda 2021 set ambitious goals that primarily target science, technology and innovation (STI) as important indicators to support the dynamic government drive.

Hence, the responsibility of human capital in promoting innovation is irreplaceable. Much attention has been given to the conceivable role of education as a strategic sector in the UAE vision 2021 in order to foster a new generation of students who are endowed with ambition, leadership and entrepreneurship characteristics. So, it was stated “Innovation, research, science and technology will form the pillars of a knowledge-based, highly productive and competitive economy, driven by entrepreneurs in a business-friendly environment where public and private sectors form effective partnerships” (UAE vision 2021, 2009). Regarding achieving this ambitious development, the main building block of successful implementation of STIP is producing a new generation of UAE skilled students to satisfy the needs of the workforce with a high level of STEM skills, knowledge and abilities (Khaleejtimes 2015; Shaer et al. 2019). Consequently, students in high school should be trained via meaningful STEM practices in order to enhance innovation and increase entrepreneurial opportunities among learners (World Bank, 2008).

The main goals of the UAE Agenda 2021 currently fall under the new agenda of 2031. The National Advanced Sciences Agenda 2031 of the UAE was launched in April 2018 to support the consistent efforts of the UAE government to achieve 2021 objectives and vision. This will be achieved through utilizing the applications of advanced sciences to effectively create and develop better innovative solutions for future obstacles and challenges. Accordingly, key enablers were developed and emphasized in the UAE Agenda 2031, which are; the economic information services, a coherent scientific community, a supportive technology and entrepreneurship in science and technology (UAE government 2019). In addition, the UAE Centennial plan 2071 was launched as a long-term plan for 5 decades starting from 2021, to reflect a full vision of UAE government work. Thus, the main aim of the Centennial plan 2071 focuses on how to make the UAE the best country in 2071 through consecutive strategies that contains four key pillars which are

- Future-focused government: UAE inspirational leadership works to establish the UAE government as the best one in the world.
- Excellent education: The main focus is in achieving high quality education that highlights advanced science and technology, space science, engineering, innovation and health sciences. Moreover, educational organizations in the UAE are encouraged to incubate entrepreneurship and innovation into its practices.
- A diversified knowledge economy: UAE economy becomes the best economy worldwide. Thus, in order to achieve this competitiveness, the UAE aims to increase the productivity of the national economy through supporting innovation, entrepreneurship and advanced industries. All of this can be achieved by producing a new generation of UAE scientists and inventors who are able to face the future challenges of the workplace (UAE government 2019).

- A happy and cohesive society: Happiness and a positive lifestyle are emphasized as well important elements of the community development in order to make the UAE one of the best places in the world.

In spite of all of these reform steps that consider the research results of how students learn to inform the best educational practices (NRC 2000a, 2000b), diversity of recent reform agendas and educational theories that seek to update and enhance teaching and learning STEM; may have caused confusion to the complex nature of STEM integration (Kelley & Knowles 2016). For instance, both Common Core State Standards for Mathematics (CCSSM) and Next Generation Science Standards (NGSS) highly advocate the purposeful integration of knowledge among STEM subjects (NGSS Lead States 2013; National Governors Association Center for Best Practices & Council of Chief State School Officers 2010). However, many problems have been recognized and documented in K-12 STEM education because of the competing theories that result in lack of coherent practices and the difficulty in identifying the crossing points or intersections for effective integration among STEM domains (NAE & NRC 2014). In order to eliminate such confusion, The Committee on Integrated STEM Education in America created a common language to support the research and practice of STEM integration through assessing current approaches implemented in STEM integration, reviewing and judging educational evidences that reflect the STEM learning outcomes, and identifying the priorities for future research studies interested in STEM integration and its reform. According to the report produced by this committee, further work is required to reform and enhance the students' outcomes in STEM practice. Besides, it calls for conducting more investigations regarding the practices of STEM education and its outcomes (NAE & NRC 2014). One of the desirable outcomes of STEM achievements is generating successful workforce that enhance the national economy of each country. Moreover, STEM education should help sustain competitive leadership within

strong economies worldwide. In this regard, Kennedy & Odell (2014) explained that “Engaging students in high quality STEM education requires programs to include rigorous curriculum, instruction, and assessment, integrate technology and engineering into the science and mathematics curriculum, and also promotes scientific inquiry and the engineering design process” (p. 246). Consequently, there is a global concern and growing urgency to close the skills gap by developing the structure of STEM education to better support the economy (Kelley & Knowles 2016). Hence, the development of STEM curriculum is considered a step forward towards restructuring STEM education. It is important to involve teachers and listen to their perceptions and understand their experiences for effective development or reform because they are responsible for delivering the curriculum to students (Meryem & Sabri 2009). It is worth knowing that curriculum evolution in most Arab countries including the UAE has been influenced by the updated educational reform and curriculum development happening in western countries in spite of the culture differences between western and non-western countries (Dagher & BouJaoude 2011). For example, the American Harcourt publications of science curricula are adopted by MOE in UAE (Alqasemy 2013). However, critiques regarding transferring western curriculum to Arab countries argued that context differences should be considered for successful curriculum design because both teachers and students of scientific disciplines are often believing that the adopted curriculum is not linked to their society (Kawagley, Norris-Tull & Norris-Tull 1998). Therefore, it was recommended to test and pilot in advance, any new models and curriculum applications that aim to meet the reform targets in order to identify difficulties and challenges that might be raised before the formal introduction of this development (Salamah 2008). Education reform is an on-going process where teachers as primary stakeholders are considered as a key element of the desired change in education because their involvement directly influences the quality of reform steps (Tabari 2014). Research studies in the responses of teachers to the requirements of education reform found

that teachers usually conveyed dissatisfaction with the new instruction that support the reform process, however they often reflect positive perceptions regarding the reform outcomes (Lee & Yin 2011). Interestingly, educational leaders observed that UAE teachers become more receptive to what UAE education reform is trying to implement in order to meet the national agenda targets 2021 (Hanif 2017). Literature pertaining to STEM education asserted that STEM teachers' perceptions are linearly related to their implementation that directly impact the development of students' skills and their understanding of the content knowledge (Han, Yalvac, Capraro & Capraro 2015). Furthermore, it was suggested that reform applications should be embedded at the school level to ensure its success (Palmer, Dunford, Akin 2009). In this essence, UAE education policy reform aims to build, develop and support the capacity of teachers to focus on positive education that enhances students' learning competencies through reducing the competition between schools of the Emirates and promoting effective long-term collaboration (Warner 2018).

Despite the increased interest in STEM learning among students (Thomas & Watters 2015), there has been a global decline of STEM students' enrolment in many countries (Kennedy & Odell 2014). However, the lack of enough STEM openings to accommodate all the STEM graduates does not reduce the need and the importance of STEM designs, outcomes and production in the world.

1.1 Research Background

There has been a consistent emphasis for more technical applications, innovation and creativity in the educational practices to enrich the STEM professions (Asghar, Ellington, Rice, Johnson & Prime 2013). Attention given to this concern is supposed to produce the essential tools for the national development as well as industrialization through expanding the habits of scientific attitudes that help students steadily acquire the constructive reasoning skills and become more confident in inquiring into real-life problems (Aguale & Agwagah,

2007). Hence, entrepreneurship and innovation are critical contributors to the economic prosperity of the country. The most natural strategy of stimulating real-life applications that enhance students' productivity is the reinforcement and development of students' skills through integrated disciplines (Adeyemo 2009). Interestingly, integrated curricula in general, STEM education in particular has a great potential to promote students' learning opportunities by connecting the classroom objectives and tasks to the most relevant real applications outside the school. Despite this, the ultimate meaning of curriculum integration is still ambiguous and consistently debated (Shaer et al. 2019), the most effective integrated curriculum is the one that reduces, minimizes or blurs the boundaries between disciplines (Beane 1995).

At the same time and in light of the idea of knowledge economy, entrepreneurship takes new significance because knowledge generated and developed in one field can become commercialized in another field through implementing entrepreneurial practices and creating new venture (Dahlstrand & Stevenson 2010; Van Horne, Huang & Al Awad 2012). Moreover, it was found that the complexity of STEM applications promotes STEM outcomes, which encourage the applications of entrepreneurship (Aslam, Abu-Ageel, Alfatlawi, Varney, Thompson & Aslam 2014). This means that the ability to generate successful STEM students who can place themselves in the labour market or STEM occupation affects the strength of the economy. Unfortunately, UAE students are underperforming in international assessment such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) that measure students' performance in disciplines (math and science) that are required in STEM education (MOE 2013). Moreover, few UAE students choose to study STEM subjects as a major, which causes a shortage in the STEM workforce of the UAE (Moonesar, Mourtada, Shaer, Al-Eisawi & Elomari (2015). This problem has caused STEM disciplines to become a national priority in UAE. Additionally, the European policy department reported

obstacles to the economic growth that involve evidences of persisting skills shortages as well as high unemployment rates in STEM fields. Lack of sufficient learning experiences that are provided to enhance students' skills were considered as a main reason of recruitment difficulties in relation to STEM (Caprile, Palmen, Sanz & Dente 2015).

On the other hand, a report produced by the Global Entrepreneurship Monitor 2011 estimated that it is expected that each nascent entrepreneur would hire at least five employees (Kelley, Singer & Herrington 2012). Accordingly, improving the number of young entrepreneurs is suggested to be connected to wealth creation, profit enhancement and economic development (Luke, Verreynne & Kearins 2007). Furthermore, entrepreneurial literatures indicate that introducing new products and valuable services potentially help create new markets to the customers. Therefore, developing students' entrepreneurial behaviour and thinking is beneficial to increase productivity that supports competition in differentiating ideas of business creation (Hitt, Ireland, Camp & Sexton 2001). In this essence, UAE education was called to an effective action through investing in STEM education, which targets students' acquisition of intellectual abilities and imaginative thinking. This helps equip and prepare students for competitiveness in the job market (MOE 2010). That is why the Abu Dhabi Education Council (ADEC) stressed the importance of engaging both educational leaders and teachers in the process of educational transformation that mainly focus on STEM practices and result in a strong and sustainable culture of education in order to generate more entrepreneurs and innovators in all fields (UAEinteract 2015). Thus, it was argued that if the noble educational objective is to transfer learning experiences into real life applications, then constructing students' entrepreneurial identity needs to be emphasized as a goal to enhancing their learning skills (Donnellon, Ollila & Middleton 2014). The global economy becomes more competitive and STEM workers must be equipped to solve challenging dilemmas with new and creative methods influencing the world around them (U.S. Chamber of Commerce Foundation 2015). Therefore, STEM labs and design rooms are becoming available in most

Dubai schools as the step toward the installation of STEM in the UAE. Moreover, professional development summits about the importance of STEM and its applications are actively provided to teachers in order to facilitate better learning opportunities to their students. The objective is to showcase their STEM outcomes during science fairs and festivals as well as science competitions and conferences about innovation and entrepreneurship (Gokulan 2018).

1.2 Problem Statement

Interdisciplinary paradigm aims to incorporate the content from STEM subjects to produce more meaningful learning experiences for students and to enhance their motivation for STEM careers. On the other hand, Ezeudu, Ofoegbu & Anyaegbunnam (2013) argued that STEM professions are not suitable and desirable for everyone. Many students have different interests and they have the right to pursue the required careers that fit their ambition. However, STEM education is still crucial for everyone because its activities can benefit all students with different career desires and allow them to think independently (Shaer et al. 2019). Basically, consistent implementation of the logical process of thinking that supports systematic problem-solving skills is considered as the core of STEM practices (Marshall & Harron 2018). Regardless students' future career choices, learning the basic knowledge about science and technology applications besides the acquisition of critical thinking and the process of solving problems can absolutely help students encounter and overcome any career challenges successfully (KhaleejTimes 2016). However, a non-experimental study conducted in an Australian University found a gap between perceptions of STEM graduates and employers regarding career development where students focused on knowledge while, employers focused on competencies that allow students to apply their knowledge (Lin-Stephen, Manuguerra & Uesi (2018). Therefore, learning that promotes meaningful STEM-related curriculum opportunities is required for better STEM outcomes (Jones et al. 2019).

In spite of the consensus in the literature regarding the prominence of STEM education, standards of integrated education and its adoption are not clearly identified in schools (Shaer et al. 2019). However, STEM students are encouraged to think creatively and to challenge themselves in order to come up with new ideas and STEM design products. The question raised by Hershman (2016) is as follows: What is the point of those STEM initiatives? It seems that such designs and creations could be easily lost unless involving basic understanding of the market. This reflects the logic of adding one more E to STEM to become E-STEM. The new E stands for integrating Entrepreneurship into STEM education (Hershman 2016). This integrated approach can make use of STEM efforts by delivering its learning outcomes through entrepreneurial practices to the market. Moreover, a report published by the Education Bureau in Hong Kong after two months of consultation to collect feedback from educators regarding STEM reform recommended updating the curricula disciplines of STEM education “to align with the on-going renewal of school curriculum with the focus on nurturing students’ creativity, collaboration, problem solving skills and innovativeness through student-centred pedagogies, and pave the way for nurturing students’ entrepreneurial spirit in senior secondary subjects such as applied learning courses” (Education Bureau 2016, p.3). Therefore, STEM educators were invited to embrace a contextualized approach to entrepreneurial learning in the STEM framework to support and expand the larger entrepreneurship ecosystem (Winkler, Troudt, Schweikert & Schulman 2015). On the other hand, the most recent report published by Mohamed Bin Rashed School of Government (MBRSG) explained the challenges facing UAE educators when applying integrated curriculum like STEAM. “Developing integrated teaching programs” (Shaer et al. 2019, p.13) is listed as one of the main challenges mentioned in the MBRSG report.

Generally speaking, students’ rehabilitation to a specific context requires an acquisition of a new set of competencies with consideration to their work function and aptitude. Thus, their repertoire of skills should be consistently developed to be more relevant to help them adjust

to the requirement and challenges of future life (Adeyemo 2009). Hence, it is imperative to prepare a new generation of STEM-literate workforce not only to be equipped with the required skills of employability but also to be capable to engage their interdisciplinary skills and thinking in the context of self-employment. Therefore, STEM education should be re-structured to include entrepreneurial practices in order to reshape the environment of the STEM context to be business-like allowing the enhancement of education for not only employment but also self-reliance (Ezeudu et al. 2013; Winkler, Troudt, Schweikert & Schulman 2015). In this essence, integrating entrepreneurial practices with STEM education seems beneficial to enhance the overall ability of STEM students to practice and perform entrepreneurial activities more effectively (Man, Lau & Chan 2002).

A recent study conducted to investigate science teachers' readiness to STEM implementation in the UAE found that although teachers are interested in STEM education, many of them are not ready for successful implementation and suggested establishing a unified STEM curriculum or framework for both public and private schools to provide equal STEM opportunities to all UAE students and to better guide teachers as to the best STEM practices (Eltanahy 2018). It was argued that entrepreneurship is a key element that introduces students' capability of translating their understanding of STEM disciplines. In this regard, a new teaching framework was developed to infuse entrepreneurship to advanced technical STEM courses and the results of this study reflected an overwhelming positive feedback from participants, who believed that such an integration can address many of challenges that face modern STEM education (Sidhu, Iqbal, Fred-Ojala & Johnsson 2018). Further, a prior research study found that STEM learning experiences in high school are crucial in fostering and influencing future practices of learners (Means, Wei & Peters 2018). Moreover, it was found that entrepreneurial competencies could be engendered in the students in high school in an experiential learning environment that focuses on entrepreneurial activities (Birdthistle, Costin & Hynes 2016).

Earlier, several research findings and reports in the literature identified the STEM practices and pointed at the contribution of integrating knowledge in promoting teaching and learning and enhancing students' outcomes (Asghar, et al. 2013; Almekhlafi & Almeqdadi 2010). In this essence, Kelley & Knowles (2016) proposed a framework of integrated STEM disciplines and presented the main STEM practices in each discipline based on the available STEM literature. However, the relationship between STEM practices and students' entrepreneurial competencies is still ambiguous because it has not been investigated yet. Thus, understanding the actual STEM learning opportunities that are currently available is critical to instilling entrepreneurial mindset in STEM students. Therefore, investigating how entrepreneurial practices can be incorporated into STEM education is warranted to enhance students' entrepreneurial identity and career choice.

1.3 Purpose & Research Questions

The purpose of the current study is multifaceted: (1) to explore educational leaders' views about incorporating entrepreneurial practices into STEM education, (2) to investigate the effective entrepreneurial practices within STEM classes that enhance incorporating entrepreneurial practices into STEM education as well as the challenges of successful incorporation, (3) to investigate participating teachers' demographics variables in relation to incorporating entrepreneurial practices into STEM education, (4) to develop a model of an entrepreneurial-STEM education (E-STEM), (5) to explore E-STEM teachers' beliefs regarding the impact of implementing an E-STEM model on students' learning outcomes and (6) to examine the effect of E-STEM practices on students' entrepreneurial competencies. Thus, the study aims to incorporate entrepreneurial practices into STEM education through the development of an E-STEM model as a new educational practice that builds upon integrating knowledge and practices from different disciplines through an interdisciplinary approach in order to promote students' entrepreneurial competencies. To achieve this six-

fold purpose, the current study was carried out to answer the following questions regarding stakeholders' perceptions about infusing entrepreneurial practices into STEM education.

- 1.What are the educational leaders' views about the incorporation of entrepreneurial practices into STEM education in the UAE?
- 2.What are the effective practices within STEM education that enhance the incorporation of entrepreneurial practices into STEM education in the UAE?
- 3.What are the main challenges that might prevent incorporating entrepreneurial practices into STEM education in the UAE?
- 4.Are there any different responses of participating teachers based on their demographics regarding incorporating entrepreneurial practices into STEM education?
- 5.What beliefs do E-STEM teachers have regarding the impact of implementing an E-STEM model on students' learning outcomes?
- 6.What is the effect of E-STEM practices on students' entrepreneurial competencies?

The following concepts have been mentioned consistently throughout the study and it is useful to be defined for clarification.

Entrepreneurship: “is when you act upon opportunities and ideas and transform them into value for others. The value that is created can be financial, cultural, or social” (Moberg et al. 2012, p.14).

Entrepreneurial learning: an approach of “Learning-by-creating-value” (cited in Lackéus 2015, p.11).

Competency: “the capability to apply a set of related knowledge, skills, and abilities to successfully perform functions or tasks in a defined work setting” (Entrepreneurship Competency Model 2010, cited in Arafeh 2016) and “an ability to perform certain tasks for which knowledge, skills, attitudes and motivations are necessary”(Gibb 1990, p. 21).

Entrepreneurial Competencies: “a set of higher-level characteristics involving personality traits, skills and knowledge. They can be viewed as the total ability of the entrepreneur to perform his role successfully” (Wen-Wu 2009, p. 281).

Entrepreneurial Knowledge: necessary information and useful experiences that have been learnt and successfully gained during carrying out an entrepreneurial activity (Jack & Anderson 1999).

Entrepreneurial Skills: “the basic skills necessary to enable you start, develop, finance and succeed in your home enterprise” (Adeyemo 2009, p. 58) or “skill is the ability of an individual to exploit an idea and create an enterprise (small or big) not only for personal gain but also for social and developmental gain” (Olagunju, 2004 cited in Adeyemo 2009, p. 59).

Entrepreneurial Attitude: “one’s own abilities that allow individuals to turn their creative ideas into action” (Tsakiridou & Stergiou 2014, p.109).

Competency-based approach: the learning approach that “focuses not only on learning or acquiring skills and knowledge, but on each individual’s way of thinking, the development of learning skills and of creative potential” (Dedovets & Rodionov 2015, p.3292).

Integrated STEM education: “approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects” (Sanders 2009, p.21).

1.4 Significance of the Research Study

One of the most crucial responses of the UAE government to the consistent changes in the world is reforming the system of its education. The UAE believes that successful reform initiatives, which produce skilful students to the workplace can highly support the dual goal of the Fourth Industrial Revolution (4IR) of empowering productive economy as well as avoiding undesirable levels of unemployment in the UAE (Shaer et al 2019). In this essence,

STEM curriculum reform has been a popular and important response to the workplace requirements. The number of research studies concerned with integrated pedagogical practices in different levels of education is growing steadily in international literature (Öztürka & Olgana 2016). To the best of the researcher's knowledge, most of the studies examined integrating entrepreneurial practices in STEM education in high school (Ezeudu et al. 2013) as well as in higher education (Hershman 2016; Hill 2016; Winkler et al. 2015) focused more heavily on the theoretical point of view. A very few of them conducted empirical studies to investigate integrating entrepreneurial practices in science in secondary education (Adlim et al. 2014) and applying entrepreneurial teaching methods in STEM in higher education (Sidhu et al. 2018). Despite the theoretical emphasis that support incorporating entrepreneurial practices into STEM education, none of the research studies mentioned that this theoretical base was able to address the dilemma of how entrepreneurial practices could be incorporated into STEM education to enhance entrepreneurial competencies of high school students. Adding to that, Hamad et al. (2016) advocated the urgent need for promoting entrepreneurial learning in the UAE and proposed that schools and colleges should be partially funded by the government to encourage students for taking risks through planning entrepreneurship initiatives. As a response to all of the previous reform calls, the current study attempts to focus on the required and recommended reform of STEM education (Bayer Corporation 2012) through creating and introducing an educational model such as E-STEM through an innovative method derived from integrated pedagogical practices to guide STEM teachers to the best practices that help develop entrepreneurial competencies of STEM students in UAE high school. The findings will add to the body of knowledge, how to further integrate business, represented by entrepreneurial practices in the integrated STEM disciplines. It is imperative to shift the STEM paradigm from only focusing on STEM knowledge and skills to be expanded to accommodate new steps towards E-STEM based curriculum that enhances a competency profile of students. Accordingly, the

implementation of an E-STEM model could influence the policy extension of science, technology and innovation (STIP) in the UAE.

Hence, the current research uses insights and beliefs of participating educators in the UAE context to incorporate entrepreneurial practices into STEM education by developing (E-STEM) as a new educational model that builds upon integrating knowledge from different disciplines through interdisciplinary approach in order to promote students' entrepreneurial competencies. Findings of the current study provide suggestions to promote the quality of STEM education through emphasizing the effectiveness of hands-on entrepreneurial activities in UAE schools. The framework of E-STEM that is developed and tested in the current research could be re-applied with or without further modifications to enhance integrated relevant knowledge from both entrepreneurship education and STEM education. Thus, infusing entrepreneurial practices into integrated STEM education via E-STEM implementation is a tangible solution to close the gap between STEM outcomes and the market. Adding to that, the findings help assist in re-structuring, planning and developing the current STEM curriculum in the UAE, which means that it is an attempt to inform decision and policy makers as well as curriculum developers to best enhance teaching instruction in the UAE. In this essence, a new agenda will be established for future educational decisions related to best STEM practices and implementation. Moreover, E-STEM model is an attempt to support teachers to be able to scaffold STEM students via integrated knowledge and practices from both entrepreneurial and STEM fields. According to that, further STEM studies will be needed in the future to investigate the effectiveness of E-STEM model in different age groups and contexts.

In a nutshell, the study results are likely to deliver new insights that should enhance and impact the uptake of integrating entrepreneurial practices into STEM education in the UAE. Moreover, the inquiry has the potential to guide the STEM education reform to give more

emphasis on the value of students' STEM outcomes and how it could be used and employed more effectively with an eye to what remains to be done to boost STEM entrepreneurship rates in the UAE.

1.5 Education Context of the UAE

The vision of UAE was outlined in 2010 for the next eleven years and stated that UAE aims to stand as one of the best countries all over the world (UAE Vision 2010). In order to achieve this great ambition, science, technology and innovation were considered as a remarkable policy in the National Innovation Agenda of the UAE where main national priorities were identified to witness significant economic revolutions. Education has to work harder to support the new vision of the UAE economy where promoting both technology and innovation has perceived as the main cornerstone in the transition of economy from oil-based to knowledge-based. Owing to this emphasized vision, education was identified as the most significant sector in the UAE that carries the responsibility of building a competent human capital in order to support the economic development of the country.

The UAE system of education has three main sectors (public, private and higher education). Majority of public schools adopt the Arabic curriculum and few of them implement science and math curricula in English. Whereas 17 of different types of curricula are implemented in different private schools. Ministry of education (MOE) as a federal government authority govern all the UAE private schools except in Abu Dhabi (regulated by ADEC), and in Dubai (regulated by KHDA). Both of the two regulators ADEC and KHDA are not federal but Emirate level government authorities. However, all of these three powerful-educational bodies (ADEC, MOE and KHDA) emphasize the education reform and keep the UAE cultural identity, local principles and valuable tradition preserved.

- The Ministry of Education (MOE): the education system in the UAE Northern Emirates (Umm Al Quwain, Ras Al Khaimah, Sharjah, Fujairah and Ajman) is monitored by MOE.

Thus, reform activities are developed and inspected in the public schools by MOE where the main focus is given to the learning standards in each educational level.

- Abu Dhabi Education Council (ADEC): Private schools found in the UAE Western Region, Al Ain and Abu Dhabi are all under the supervision of ADEC authority that was established in 2005. School licenses and their accreditation are also provided by ADEC. Therefore, the work of ADEC and its regulations is closely related to the MOE in order to formulate a strong reform plan that directly supports the education system. Accordingly, the schools' buildings, its safety, students' health, requirements of its site as well as the educational outcomes are all considered in ADEC's work. In this regard, registration of all private schools at these previous Emirates with ADEC is a must by UAE law since 2008. Moreover, regular inspection is done to all of the schools to measure the performance of the school in the light of its strengths and weaknesses, and then the progress of the school is reported to ensure the provision of a quality education. In order to build rigor, ADEC established The Private Schools and Quality Assurance (PSQA) in Abu Dhabi to implement an effective strategic plan to help enhance the progress of schools' education to meet the UAE National Agenda targets. Further, in 2010, His Highness Sheikh Mohamed bin Zayed Crown Prince of Abu Dhabi established The Abu Dhabi Centre for Technical and Vocational Education and Training (ACTVET) that seeks to support the technical and vocational education via effective learning institutes in all Emirates that aim to generate skilled Emirati youth who are ready for future career challenges.
- Knowledge and Human Development (KHDA): Private schools in Dubai Emirate are under the supervision of KHDA that was established in 2007 to ensure consistent progress and proper quality of UAE education. Thus, the main work activities of the KHDA is collecting and analysing data of the schools being inspected, facilitating educational services, providing permission, statement of educational standards. More interestingly, KHDA emphasizes the happiness of students in Dubai. Accordingly, a new program (The School of Hearts) was

launched as a new initiative to build a suitable balance between personality development of students and their academic achievements. Similar to ADEC, there is a partnership between KHDA and MOE to ensure high quality of education system in all sectors of education (public and private) of the seven Emirates.

1.6 UAE Initiatives towards Education Reform

Many important initiatives were coordinated and announced by the educational authorities in the UAE (MOE, ADEC, KHDA and ACTVET) to support the education reform (UNESCO 2016) such as the teacher licensing program. The Teacher and Educational Leadership Standards (TELS) aims to ensure that UAE teachers are professionally competent. Thus, the international best practices of teaching and learning processes are adopted in the light of learning standards that meet UAE vision. For UAE teachers, in order to be certified, they are required to attend professional development programs (PDPs) and then take part in assessments that are carefully designed to measure, enhance and standardize their instructional practices and teaching skills.

Abu Dhabi as the capital of the UAE, reported other important development programs in the education field that are lined up with the strategy of the federal education that chose the decentralization of the educational sector and a more noteworthy contribution of the private division, side-by-side with the public division in upgrading competitiveness and quality (AbuDhabi Digital Government 2018). In this essence, Abu Dhabi established a new department that is called, The Department of Education and Knowledge to manage and guide as well as implement a variety of modern educational strategies and development initiatives in the light of Law No. 24 enacted by His Highness Sheikh Khalifa bin Zayed Al Nahyan, UAE President. In this essence, the curriculum development continues to receive a considerable support in education through applying new programs to better cope with the revolution of science and technology. The Emirate Abu Dhabi believes that consistent

development of the academic curriculum of schools is essential to equip UAE students with the required skills to be able to take up leadership roles and invade the job market successfully in different respectful fields in order to meet the needs of the UAE economic expansion. According to that, a new project named, Public Private Partnership (PPP) was launched as a part of the overall development plan seeking to enhance the cooperation between both public and private sectors to improve the quality of education. Under the framework of this project, the partnership of these two pillars in education is perceived as beneficial because it allows both administrators and teachers to share teaching and learning experiences in order to generally improve the quality of instruction that influences students' outcomes. Thus, educators and supervisors who are responsible for the progress of this project work with school staff to construct a world-class instructive framework that fortifies the culture of the UAE as well as its respectful traditions (AbuDhabi Digital Government 2018). In order to build rigor, Abu Dhabi Education Council (ADEC) established The Private Schools and Quality Assurance (PSQA) in Abu Dhabi to implement an effective strategic plan to help enhance the progress of schools' education to meet the UAE National Agenda targets. Further, in 2010, His-Highness Sheikh Mohamed bin Zayed Crown Prince of Abu Dhabi established the Abu Dhabi Centre for Technical and Vocational Education and Training (ACTVET) that seeks to support the technical and vocational education via effective learning institutes in all Emirates that aim to generate skilled Emirati youth who are ready for future career challenges. Evidently, all of the previous approaches and initiatives by MOE, KHDA and ADEC seek to achieve and measure the progress of the same National Agenda goals 2021, which are to establish a world-class education system by collecting data and evidence from international standardized exams to effectively benchmark knowledge of the UAE against the competitive educational achievements in the world (Warner 2018).

1.7 STEM and Entrepreneurship in the UAE

Educational researchers and proponents of STEM education argue that effective implementation of STEM has the potential to contribute to students' meaningful learning experiences. Thus, STEM practices are perceived with enough credibility worldwide to generate solutions for future problems (Roberts & Cantu 2012). In this regard, all UAE schools are encouraged to implement STEM practices and activities in their classes. However, STEM implementation in the UAE is similar to many of the developing countries that focus on the integration of science and math activities (Pennington 2017). Many schools emphasize project-based learning techniques through an alignment to the learning outcomes of the four STEM subjects. This project usually has success criteria in order to guide students to be aware of what is expected from them. The emphasis of the project rubric is usually given to the design and the main competencies developed during this STEM activity. A group of schools around the UAE established a unified STEM curriculum to better monitor their STEM applications in order to meet the demand of the UAE labour market (Pennington 2017). Meanwhile, the literature of STEM education reform does not reflect a consensus about the main components that constitutes STEM education (Pitt 2009). However, UAE Vision 2021 recommended applying effective pedagogical strategies such as project, problem and inquiry learning in STEM classes to enhance the learning process. In this regard, Matsumoto (2019) reviewed the literature of UAE education reform and recommended that UAE policy makers should consider the common values that can strongly impact UAE culture when defining and planning for future education reform programs.

There has been a great emphasis during the last few years regarding enhancing entrepreneurship education in the UAE (Bradstreet & Dun 2013) because it is being recognized as an essential tool to create new job opportunities and economic independence for youth. Therefore, education was called for action because it is a prerequisite for enhancing entrepreneurial initiatives that help raise productivity in all economic zones. Although

technology-oriented venture is strongly encouraged in the UAE (Hamad et al. 2016), only 2.3% of new ventures started in the UAE rely on a medium or high-technology level (Van Horne et al. 2012). More recently, the Global Entrepreneurship Monitor (GEM) recorded the entrepreneurial behaviour and attitude in the UAE and reported that the percentage of perceived capabilities rate that refers to individuals who are involved in any new entrepreneurial activity dropped from about 65% in 2017 to 54% in 2018. Similarly, the percentage of entrepreneurial intention rate reduced from 61% in 2017 to 37% in 2018 respectively (GEM 2018). Therefore, motivating STEM students to become entrepreneurs is beneficial because of the high level of technology implementation that could be seen in their future venture creation (Hershman 2016).

1.8 Overview of the Research Study

The current study is presented in five main chapters. The first chapter provides a clear introduction to describe as precisely as possible the phenomenon of STEM education and the emphasis of restructuring the integrated STEM disciplines to help prepare students for the future requirements of the workplace. Those requirements in turn meet the target of reform programs in UAE education that seek to promote the shift of economy paradigm from oil-based to knowledge-based. Moreover, background information is provided for the new significance of entrepreneurship and its relation to STEM education to best support the economic growth of the UAE. Likewise, the problem and rationale of incorporating entrepreneurial practices into STEM education have been incorporated to highlight interesting historical literature that identifies the gaps in the research. Furthermore, the significance of the current research has been demonstrated by explaining the impact of creating and implementing the E-STEM model in all the stakeholders that support the education reform process. Purpose statement and six research questions have been posed to clarify how the current study seeks to close the gaps in the research. The context of UAE

education has been described to shed light into the structure of UAE education and the main authorities whom are responsible for the reform process in general and particularly curriculum development. The second chapter provides a detailed review of the historical and recent research studies regarding STEM education, entrepreneurial learning and their theoretical relationship that has been discussed in the literature to promote the possibility of integrating them to develop a set of common entrepreneurial competencies. Additionally, the conceptual and theoretical frameworks are introduced earlier in graphs and explained clearly to support the study claim and guide the path of the study. Thereafter, the third chapter explains the mixed methodology selected to conduct the study, the two stages of the multiphase mixed design have also been identified where the exploratory stage aims to develop the E-STEM model and the confirmatory stage aims to test this model in a high school in the UAE. In addition, site selection, sampling techniques and recruiting participants have all been recognized and justified. A precise description concerning the research context has been comprised. A multiple instrumentation of the two stages has been defined including focus group interviews with the STEM educational leaders and STEM teachers' questionnaire in the exploratory stage. Whereas, the confirmatory stage adopted another two instruments such as face-to-face interviews with the E-STEM teachers and distributed a questionnaire to students. The fourth chapter explains how the data gathered from both qualitative and quantitative instruments in the two methodological stages have been analysed. The final chapter in this study focuses on the discussion of the attained results, the logical conclusion along with the future implications and relevant recommendations that support the research agenda of future investigations.

CHAPTER 2: THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Overview

The current study seeks to incorporate entrepreneurial practices into STEM education and develop an Entrepreneurial-STEM model as a new educational model that builds upon integrating knowledge from different disciplines (science, math, engineering, technology and business) through interdisciplinary approach in order to promote students' entrepreneurial competencies. Hence, there is a growing effort in the UAE to support enhancing scientific innovation and to produce more entrepreneurs (Hameed, Khan, Shahab, Hameed & Qadeer 2016; OECD 2016). The key issue is how can STEM courses in education go beyond the content delivery and truly support the economic growth of the country so that STEM learners can develop a broad mix of both STEM and entrepreneurship skills (Ezeudu et al. 2013). Building on this endeavour, the literature focuses mainly on higher education to give an insight into how the curriculum of science, technology and math (STM) can be re-structured to include entrepreneurship, ensuring not only the proper education for employment but also for self-reliance (Ezeudu et al. 2013) through expanding the range of learning opportunities and experiences made available for students. That is why researchers suggested that entrepreneurial practices could be effectively infused into existing STEM programs (Winkler et al. 2015) in order to develop the entrepreneurial learning of students. Consequently, Hill (2016) suggested an entrepreneurial characteristic profile that includes eleven competencies that can be enhanced via integrating entrepreneurial learning with STEM courses. Moreover, a smaller set of entrepreneurial competencies were measured for primary school students to examine their potential to become entrepreneurs in the future (Taskiridou & Stergiou 2014). Although not much attention is given in the literature to how this incorporation can be implemented in high school, the previous academic perspectives reflect the desire and the need to investigate new pedagogical models that enhance this incorporation in secondary

education as well because it is never too early to acquire some entrepreneurial competencies (Warhuus & Basaiawmoit 2014; Winkler et al. 2015). In order to achieve the learning goals of this education level, education-through entrepreneurship is emphasized as the main approach of incorporating entrepreneurial practices (Johannisson 2010). Thus, this approach focuses mainly on the pedagogy rather than the content through implementing competency-based teaching strategies (Lackéus 2013). Accordingly, the study investigates the relationship between the E-STEM practices and students' entrepreneurial competencies through elucidating what STEM education will look like when entrepreneurship is integrated into its practices. Precise attention is paid to the theoretical and conceptual frameworks that guide the possibility of incorporating entrepreneurial practices into STEM education. Theories that support the study assumption are all explained in the following section.

2.1 Theoretical Framework

Grant & Osanloo (2014) explained that the theoretical framework introduces the constructs, concepts and principles of all theories that provide a common lens to guide the path of the study. The purpose of the current study is to incorporate entrepreneurial practices into STEM education through establishing an educational model that enhances students' entrepreneurial competencies. Relevant theories supported the study claim from both STEM education and EE are employed and explained in this section in order to deepen the essence of the research inquiry. The following graph identifies a variety of educational theories that are used to support the study claim.

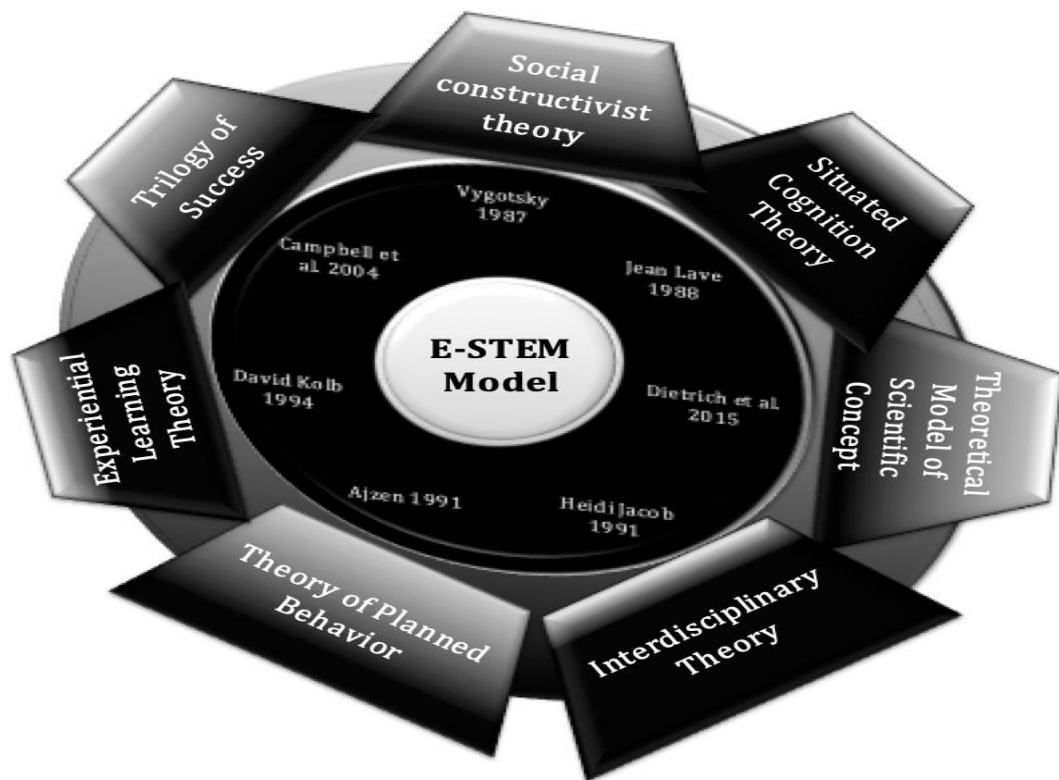


Figure 1: Theoretical Framework of the Study

Figure 1 identifies the seven educational theories that are reviewed and discussed to reflect the alignment of entrepreneurial practices with STEM education in the developed E-STEM model. The selected theories reflected that the current investigation is worth supporting because it is firmly originated based on a variety of established educational theories elicited from credible sources (Adom, Hussein & Agyem 2018). The following paragraphs provide more detailed information about each theory.

2.2.1 Social Constructivist Theory

Constructivism in general is a guiding philosophy adopted for this study. The central figures of its philosophical assumptions are designed by prominent philosophers in this field of cognition and learning theory: Jean Piaget, Eleanor Duckworth, Bruner, Howard Gardner (Ronis 2008), Vygotsky and Von Glasersfeld. They identified the main features of

constructivist practices (Hadjerrouit 2005) where the shift from teacher-centered to student-centered is highly recommended. Thus, social constructivist theory explains how students actively construct knowledge in social learning environment (Vygotsky 1987). The Zone of Proximal Development (ZPD) is a key element in Vygotsky's theory as it refers to the capacity of students to learn more knowledge with assistance of others. That is why, Vygotsky explained another important theme that is the more knowledgeable other [MKO], which can be an older adult like the teacher or a younger person like peers. Thus, the social environment was considered as a critical factor for effective learning where effective interactions help transform important learning experiences (Schunk 2008). A set of pedagogical guidelines such as construction, cognitive skills, authentic tasks, related cases, collaboration and information technology are listed based on the constructivist theory and are recommended because they all can be translated into educational practices (Lin & Hsieh 2001; Steffe & Gale 1995; Tam 2000; Wilson 1998). In this essence, social constructivist theory emphasizes the direct interaction with others where learning knowledge is perceived as a negotiated human construct. Many pedagogical approaches are derived from this theory such as problem-based learning (PBL), project-based learning (PjBL) and inquiry-based learning (IBL) where learning is best experienced through hands on activities (Ronis 2008).

Albert Bandura who introduced the social cognitive theory confronted preconceived notions of how learning occurs. He explained that students would imitate the behavior of a certain model they were exposed to (Bandura, Ross & Ross 1961). Thus, five main assumptions formulated this theory: 1) students can learn by observation, 2) students' behavior may change during the learning process, 3) there is a mutual influence between students and their environment, 4) behavior can be directed to achieve particular objectives, and 5) behavior is developed gradually to be self-regulated (Ormrod, 2008). This theory believes in learning by observing and following a model to achieve a task or activity.

Bandura explained that social, personal and environmental events in school are all important factors that influence students learning (Sternberg 1994) which means that the communication between students is crucial to allow them to access many related experiences. Accordingly, students can draw on previous cases to make sense of deficient knowledge. Then analogical reasoning is used to identify differences and similarities between students' previous experiences, which are useful to solve current problems. Applying inquiry-based learning strategies provide students with valuable opportunities to make use of their prior knowledge and experiences, plan, re-plan and replicate till they reach the most logical conclusion (Froebel 1887). Thus, better learning experiences occur in collaboration between groups of students not in isolation. Thus, interaction between learners during inquiries and social negotiation through discussions enriches the process of constructing knowledge (Baran, Canbazoglu Bilici & Mesutoglu 2016). Finally, it is crucial to facilitate constructivist-learning classes through utilizing technology as a quick source of multiple types of knowledge that are needed for students' research (Clark & Ernst, 2007). One of the essential approaches to construct new knowledge is to integrate current knowledge from different disciplines. Thus, integrated knowledge-based constructivist learning has its potential for enhancing the school environment (Mayer, 2004) because it can fit in different learning experiences such as problem-based learning (Goodnough & Cashion, 2006) and project-based learning (Han, Yalvac, Capraro & Capraro 2015).

According to Vygotsky's constructivist philosophy, Papert (1991) developed the constructionist theory of learning that asserts that knowledge could be felicitously constructed in a learning context that allow students to be engaged in producing or designing artefacts. Therefore, constructionism theory gives more focus to hands-on designing activities where learners are consciously involved in building, making or programming new products (Kafai & Resnick 1996). These designs are usually chosen and done cooperatively based on students'

desires, learning styles and abilities to complete this challenging task. Papert adapted and developed the philosophy of 'learning-by-doing' to become more specific to achieve 'learning-by-making' new prototypes. According to this theory, the artefacts' designing process should challenge learners to apply the knowledge being explored and constructed to provide new ideas through using available digital tools (Papert 1980). Moreover, the constructionist-learning environment values the cooperation of engagement of community members as coaches or other experts who can help students in the learning process. In this regard, some key learning principles were derived from the philosophy of constructivist and constructionist theories; knowledge construction, collaboration, exploration, problem solving, designing and integrating technology (Ah-Namand & Osman 2018). In this regard, both social constructivist theory and constructionist theory are guided the current study through emphasizing the need for designing valuable STEM projects in a social learning environment.

2.2.2 Situated Cognition Theory

The literature advocated that most of the content in STEM integration is grounded in the situated cognition theory where knowledge is situated and embedded in the learning activities bound to cultural, physical and social contexts in which knowledge was constructed and learned (Brown, Collins & Duguid 1989). The credit is often given to Jean Lave (1988) regarding the situated cognition, which is highly influenced by the philosophy of John Dewey and Lev Vygotsky who adopted similar features of the effective learning approach. In general, learning models that derived from the paradigm of social constructivism reflect a significant feature of situated cognition.

Situated cognition theory calls for not only learning skills and knowledge but also understanding how they can be applied in real situation where all social and physical elements of the learning context are essential to be considered (Putnam and Borko 2000). Thus, it is a

theory of instruction that suggests offering students the learning model through providing practical activities such as cognitive apprenticeship (Collin, Brown & Newman 1990) as well as enrichment programs or opportunities in the school stage (Subotnik, Olszewski-Kubilius & Worrell 2011). Hence, the cognitive apprenticeship model is associated with the situated learning theory in order to enhance the acquisition of lifelong skills that emphasize the communication with either experts or colleagues through the application of authentic context-based learning. Teachers who apply situated learning approaches understand entirely the possibility of cultivating the learning culture through sharing multiple perspectives and beliefs among the students' groups. Thus, expanding the process of learning by discussing, negotiating, presenting and giving reasons can strengthen the learning concepts (Lave 1988). In this essence, learning through traditional setting that has unnatural activities is more difficult than authentic experiences that expose learners to meaningful learning opportunities. Accordingly, learning context, authentic practices of activities and culture are the three key aspects that are naturally linked to the situated cognitive theory (Brown et al. 1989). Thus, the importance of enrichment opportunities is emphasized in the school stage because it allows students to work on challenging and exploratory activities that fuel the development of their learning skills in real life environment (Subotnik et al. 2011).

Thinking of an effective situated approach of learning for any academic course will take you away from the classroom and launch you in the direction of apprentice-like situations which allow students to learn by working with experts. For example: in the past, architects used to learn how to design buildings by working, interacting and assisting other master architects. Vygotsky recommended planning authentic activities or tasks that are slightly more difficult than what the students are used to achieve, so they can address its dilemma in cooperative groups. In other words, assignments should be situated in the students' zone of proximal development (ZPD) just beyond their levels and appropriate level of collaboration and engagement can help them to learn how to solve it (Vygotsky 1987). This means that

Vygotsky advocated the situated learning through apprentice-like coaching. Based on situated theory, STEM learning process in the light of design-based approach is relevant and authentic because it is grounded within practice-based context that capitalizes on the situated STEM learning where engineering design is the situated platform (Kelley & Knowles 2016).

2.2.3 Interdisciplinary Theory

Integration is defined as a harmonious relationship between interdependent realms of knowledge (Meeth 1978). Piaget (1972) referred to any form of knowledge that has its own unique characteristics as a discipline. Accordingly, discipline field was defined as, “A specific body of teachable knowledge with its own background of education, training, procedures, methods and content areas” (Piaget 1972, cited in Jacobs 1989, p.7). Interestingly, Heidi Jacob suggested integrating knowledge from different fields of learning to make more meaningful learning experiences rather than teaching disciplines concurrently (Jacobs 1991). Accordingly, she designed models of integrated knowledge based on the level of integration between disciplines where interdisciplinary approach is highly recognized as a medium level of integration (Brandt 1991).

The development of interdisciplinary theory has been passed through three chronological stages that are called “Pre-theory”, “theory” and “expanding theory” (Newell 2013, p. 22) that all link the changes of the interdisciplinary concept and how far it has progressed (Newell 2013). Thus, the concept of interdisciplinary was introduced to the educational context in 1955 (McCuskey & Jensen 1955). However, it was widely mentioned in quite casual discussions in education reform because its definition was modest (Mayville 1978). The Association of Interdisciplinary Studies (AIS) in the USA adopted the definition of this concept where its founders focused initially on the meaning of integrating different disciplines (Newell 2013). For example, Richard Meeth stated that interdisciplinary programs reflect an “attempt to

integrate the contributions of several disciplines to a problem, issue, or theme from life” (Meeth 1978, p. 10).

Accordingly, Earl McGrath highlighted that the main purpose of utilizing interdisciplinary work is to integrate knowledge of different disciplines that are related to a particular issue (McGrath 1978). The literature of interdisciplinary published the first definition that reflects the core of AIS discussions about this theory where interdisciplinary studies were defined as “inquiries which draw critically on two or more disciplines and which lead to an integration of disciplinary insights” (Newell & Green 1982, p. 24).

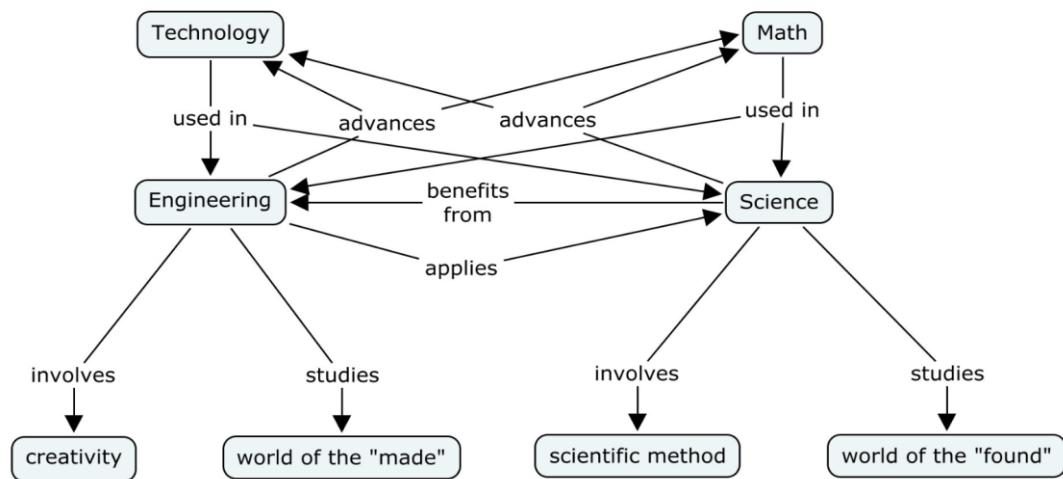


Figure 2: Value of Interdisciplinary Approach (Thornburg 2008, p.3)

Figure 2 demonstrates the concept map of STEM disciplines that identifies the educational connections between the main four course contents. According to the figure, the main courses of knowledge are thematically linked through involving students in scientific inquiry experiences in order to stimulate creativity and innovation. Thus, the dynamic linkages between disciplines are frequently evolving over time. Engineering applies scientific concepts and science adds benefits to engineering designs. Moreover, advances in both engineering and science help enhance the development of new techniques in math. At the same time, mathematics skills are critical for applying both engineering and scientific investigations.

While, the power of technology is highly required to benefit learning of the other disciplines (Thornburg 2008). In this regard, interdisciplinary theory is relevant to guide the study through emphasizing the need for integrating knowledge and practices from different subjects to enhance the learning process.

2.2.4 Theory of Planned Behaviour

One of the most important theories for predicting the intention of the students is the theory of planned behaviour (TBP) provided by Ajzen (1991), which is basically the extension of theory of reasoned action presented by Ajzen & Fishbein (2000). The theory of planned behaviour is a theory that links one's beliefs and behaviour as it states that intention toward behaviour, subjective norms, and perceived behavioural control, can shape an individual's intentions and behaviours. Many models were developed in the light of Ajzen's theory.

The model of entrepreneurship intention was developed to identify the most important theoretical concepts responsible for enhancing students' entrepreneurial behaviour. Accordingly, entrepreneurial knowledge, students' personal attitude and their entrepreneurial intention were recognized as the important elements that motivate students to act entrepreneurially. The model pre-assumes that the association of these three factors ultimately characterizes the proclivity of students towards entrepreneurial action. In this regard, the model of entrepreneurship intention is considered as a robust conceptual framework, which has been implemented and tested in various research examinations (Jack & Anderson, 1999). The three constituent components of this model are briefly explained henceforth.

The first element is the entrepreneurial intention, which has become the best indicator of the entrepreneurial behaviour of students. This is due to the fact that it is difficult to observe this behaviour because it is not common or is mainly rare (Krueger & Brazeal, 1994). The most valuable outcomes of having an entrepreneurial intention is the ability to add new values to

existing business or the ability to start up new venture. These are perceived as two main examples of entrepreneurial behaviour (Bird 1988). Thus, entrepreneurial intention is deemed to be the purposive pursuit of establishing new business (Gartner, 1989). Moreover, it is often regarded as the dependent variable that influences the entrepreneurial behaviour of learners (Tshikovhi & Shambare 2015).

The second element is the entrepreneurial knowledge that can be gradually acquired and highly developed through the regular implementation of entrepreneurial activities (Massad & Tucker 2009). Entrepreneurial knowledge emphasizes the entrepreneurial principles, concepts, thinking focus and mentality of entrepreneurs. Accordingly, entrepreneurial learning is directly linked to the acquisition of this knowledge (Jack & Anderson, 1999).

The third element is the personal attitude of learners, particularly their desire to perform and act entrepreneurially. As indicated by Nicolaides (2011), an attitude towards certain practice is the measure of the extent to which this behaviour is favourable or not. Thus, it is considered as a mental affair that provides either positive or negative connotation towards behaving or acting entrepreneurially (Miralles, Riverola & Giones, 2012). In this regard, Tshikovhi & Shambare (2015) defined the personal attitude of individuals as “a mentally prepared state for any known subject” (p.153). Additionally, their study revealed the level of entrepreneurial knowledge is associated with the attitude that influences the intentions of entrepreneurial behaviour. Accordingly, the entrepreneurship intentions model is relevant to guide the study through highlighting the entrepreneurial intention, knowledge and attitude of the students.

2.2.5 Trilogy of Success Theory

Cognitive psychology is an important field in which its theories are used to guide educators and researchers to differentiate strategies that can be employed to enhance the learning process (Brown & Parker 2009). Therefore, motivational theories are utilized in the understanding of

how effective teaching and learning processes occur. For example, Campbell, Jolly & Perlman (2004) explained the trilogy of success in learning an interdisciplinary curriculum such as STEM. Three interrelated key factors – engagement, capacity and continuity (ECC) were identified with strong relation to successful continuation to learning. Engagement refers to the approach used with STEM that should emphasize students’ awareness, motivation and interest to learn this interdisciplinary approach. Capacity refers to possessing not only the knowledge but also the skills needed to go further in the process of learning a rigorous content such as that which STEM entails. Finally, continuity refers to the consistent learning opportunity that should be offered to students to support the learning process. This theory suggests the interaction of the three features together for further advancement along interdisciplinary content; emphasizing one of them alone is insufficient. In this regard, educational practices that are aligned for continued advancement should focus clearly on the acquisition of both knowledge and skills as well as the provision of authentic learning opportunities that enhance students’ interest and continuous success. Essentially, educational practices that emphasize the engagement (awareness, interest and motivation), the capacity (knowledge and competencies) and the continuity (learning opportunities, resources and desired outcomes) enhance students’ progress on the learning path of STEM.

The trilogy of success theory was derived from the suggested trilogy of Hilgard (1980) that clarifies how human mind works. his theory explains that cognition, conation and affection are the three main elements that interact to empower the mental activities and collectively influence the learning process and its outcomes. Cognition as a first element refers to the rational thought that affect the process of eliciting and acquiring new knowledge. Conation refers to the natural tendency or the desire that leads to a directed effort to perform as a goal-oriented person. Thus, the two core processes -motivation and volition emphasized the conation (Snow, Corno, & Jackson, 1996). Lastly, the affection refers to both the positive and negative emotions that influence students’ learning (Bower 1994). Emotional association is a

powerful tool, which aids learning as well as recalling the necessary abilities to continue learning.

2.2.6 Theoretical Model of Scientific Competencies

Dietrich, Zhang, Klopp, Brunken, Krause, Spinath, Stark & Spinath (2015) introduced a theoretical model of scientific competencies developed in social sciences. They specified four building blocks that outline this model; input, operation, output and personal characteristics. The following figure illustrates the outline of the general model of scientific competencies designed by Dietrich et al. (2015).

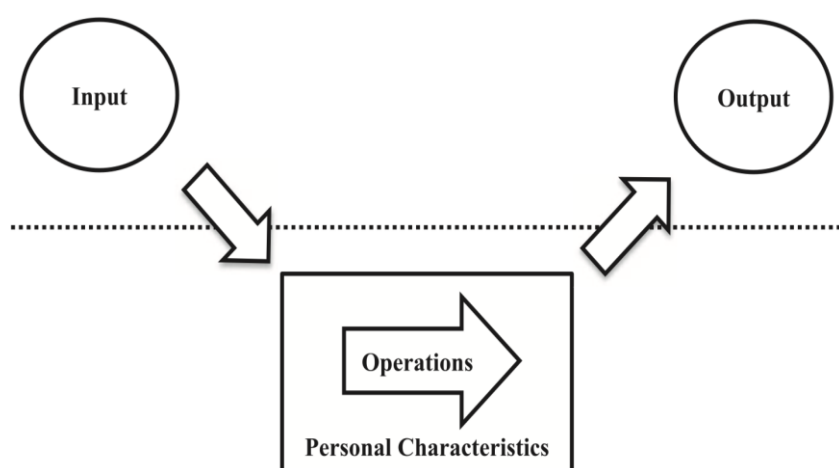


Figure 3: Overview of the General Model of Scientific Competencies (Dietrich et al. 2015, p.117)

Figure 3 shows the main four building blocks of this model. The first building block refers to the content knowledge provided or introduced to students. The second building block is the operation, which represents the cognitive process conducted to address the input. Six cognitive processes were identified in the operation; remember, understand, apply, analyze, evaluate and create. ‘Remember’ means retrieve and recall prior information that is relevant to the current learning topic, whereas ‘understand’ means construct and make meaning from the

information provided or elicited. ‘Apply’ means conduct procedures or carry out steps to help confirm or reject hypothesis whilst ‘analyze’ constitutes as identifying the relationship between the constitute parts of the overall knowledge. ‘Evaluate’ means criticize, assess and judge the results achieved to make reasonable conclusion based on standards, and ‘create’ means make new meaning from the constructive knowledge through putting all components together in order to form a functional whole. All six cognitive processes mentioned above are essential in STEM education and students typically use them during design-based problem-solving activities. Outcome is the third building block in this theoretical model, referring to the final results achieved upon applying the operation on the input. This means that the output has to be created or accomplished by the learners (Anderson, Krathwohl, Airasian, Cruikshank, Mayer, Pintrich & Wittrock 2001). Thus, the last building block is the personal characteristics that are recognized as relevant for the acquisition of competencies. Accordingly, the scientific competencies were considered as “the constructive use of operations on input and the creation of output thereby” (Dietrich et al. 2015, p.115). This model was adopted from Structure-of-Intellect Model (Guilford 1967) and was perceived as advantageous because its level of generality is relatively high. As a result, educational models that target cognitive competencies can make use of this theoretical model or draw on its framework.

2.2.7 Experiential Learning Theory

It is found that compartmentalized learning that categorized knowledge into separate disciplines does not efficiently help students solve real-life problems (Wurdinger 2005). The main hypotheses that lead to theories of experiential learning emerged in the mid-nineteenth century as endeavours to move far from abstract teaching and learning methods, where formal instructors taught theoretical ideas directly, and toward interactive techniques of learning

where students would learn by doing and successfully apply the content information when involved in different learning situations in order to develop aptitudes (Bozarth 2006). Accordingly, the main roots of experiential learning were growing based on the constructivist approach and supported by interdisciplinary learning where knowledge from different subjects is connected. David A. Kolb established the systems of experience-based learning in the 1970s and developed the experiential learning theory drawing on the philosophy of John Dewey and Jean Piaget (Kolb & Fry 1975). It was described earlier in the literature that, “In its simplest form, experiential learning means learning from experience or learning by doing. Experiential education first immerses learners in an experience and then encourages reflection about the experience to develop new skills, new attitudes, or new ways of thinking” (Lewis & Williams 1994, p.5).

Experiential learning has an open nature that leads to the development of many practical models of learning that have the potential to be considered as experiential. In this regard, Chapman, McPhee & Proudman (1995) identified the main attributes of any experiential practice in education. Firstly, it considers both content and process where the learning activity should bridge the gap between theory and practice. Secondly, it is free of excessive judgement since students should have adequate discovery-based learning opportunities to achieve the objectives of their experiential task. Also, it is being purposefully oriented, learning takes place in a student-centred environment that has purposeful endeavour as well as being relevant to each learner. Furthermore, it is connected to real world applications, activities that facilitate the holistic perspective of learning that connect the simple content knowledge taught at school to more complex systems found consistently outside. Moreover, it promotes reflection where learners have the chance to freely reflect on their practices to gain insight into their learning experiences. It is an emotional investment; learners are fully engaged in an authentic inquiry to a point where what is being applied in the educational setting strikes critical meaning to

enhance their cognitive abilities. Furthermore, it facilitates learning investigation when learning is done through self-explorations that allow students to collect and analyse available values. It provides meaningful learning experiences where relationships between learning outcomes and the requirements of real life in different contexts are identified. Ultimately, it expands the students' comfort zone: practices should operate outside the comfort zones of learners in order to challenge them and enhance their capacity of learning.

There are two main types of experiential learning that are classified according to the nature of the educational setting. The first category is called field-based experience that is usually recommended for students in higher education since the 1930s through internships, service learning, cooperative opportunities and practicums (Lewis & Williams 1994). The second category is called classroom-based experience, which refers to a multitude of forms of active learning techniques that can be implemented in the school stage including educational games, simulations, role-playing, case studies and all other types of teamwork (Chickering & Gamson 1989).

Hence, students usually implement STEM activities through either problem-based learning or design/project-based learning (Wilhelm 2014) in the school setting. While integrating entrepreneurial practices required involvement in the field of the market to start a new business in order to achieve the anticipated objectives of this incorporation. In this regard, the E-STEM model that has been proposed in the current study can be instructed more successfully with experiential activities because it reflects the nature of the two categories of experiential learning.

The foundation of problem-based learning (PBL) derives back to learning from experiences (Golding, Lamb & Tapsell 1996). This reflects that both problem-based learning and experiential learning give attention to the authentic experience and practices that encourage students to investigate in order to solve real life dilemmas. Savery (2006) defined PBL as “an

instructional (and curricular) learner-centred approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem” (p. 9).

Adding to that, there has been a substantial overlap between PBL and project-based learning (PjBL) and inquiry-based learning (IBL) because all are driven by the same constructivist approaches that emphasize working on extended investigations of authentic tasks (Cook & Weaver 2015; English & Kitsantas 2013). However, their distinctive features can differentiate them. The origin of PBL goes back to medical studies where a student-centred approach is conducted in a collaborative learning environment to find solution for an ill-structured problem (Goodnough & Cashion 2006; Walker & Leary 2009). Similarly, student-centred learning is a main feature for project-based learning but with more explicit guidance by the teacher. However, product creation is needed to solve the authentic problem (Savery 2006). While, inquiry-based learning is built on posing and investigating a certain scientific question, however, it may not really be guided by any problems or result in designing a product (National Research Council, 1996). Moreover, value creation is an experiential learning-based activity that could be enhanced in education and often classified as entrepreneurial where teachers can draw on the useful methods and tools of the entrepreneurship domain (Lackéus 2015). This meaning leans on the definition of entrepreneurial education as “Content, methods and activities supporting the creation of knowledge, competencies and experiences that make it possible for students to initiate and participate in entrepreneurial value creating processes” (Moberg, Stenberg & Vestergaard 2012, p.14).

According to this theoretical framework that introduces different educational theories, incorporating entrepreneurial practices into STEM education requires providing STEM students with authentic tasks that connect their designs to the market through social learning environment. These tasks should develop new situated platform to experience entrepreneurial

practices through integrated knowledge from different disciplines that allow students to construct entrepreneurial knowledge during meaningful learning experiences. The success of this incorporation requires well-structured instruction that enhances engagement of students in the new learning practice. In this regard, the conceptual framework was developed and introduced in the following section.

2.2 Conceptual Framework

The conceptual framework of the current research inquiry is designed in a graphical structure to best illustrate the natural progression of the phenomenon under discussion and supports its hypothesis (Camp 2001). It also explains the link between the main concepts that are emphasized in this study and refers to how the research claim would be explored and discussed. According to Professor Akintoye, the conceptual framework can provide a context for interpreting the results and enhances the theory development for future practice (Adom, Hussein & Agyem 2018).

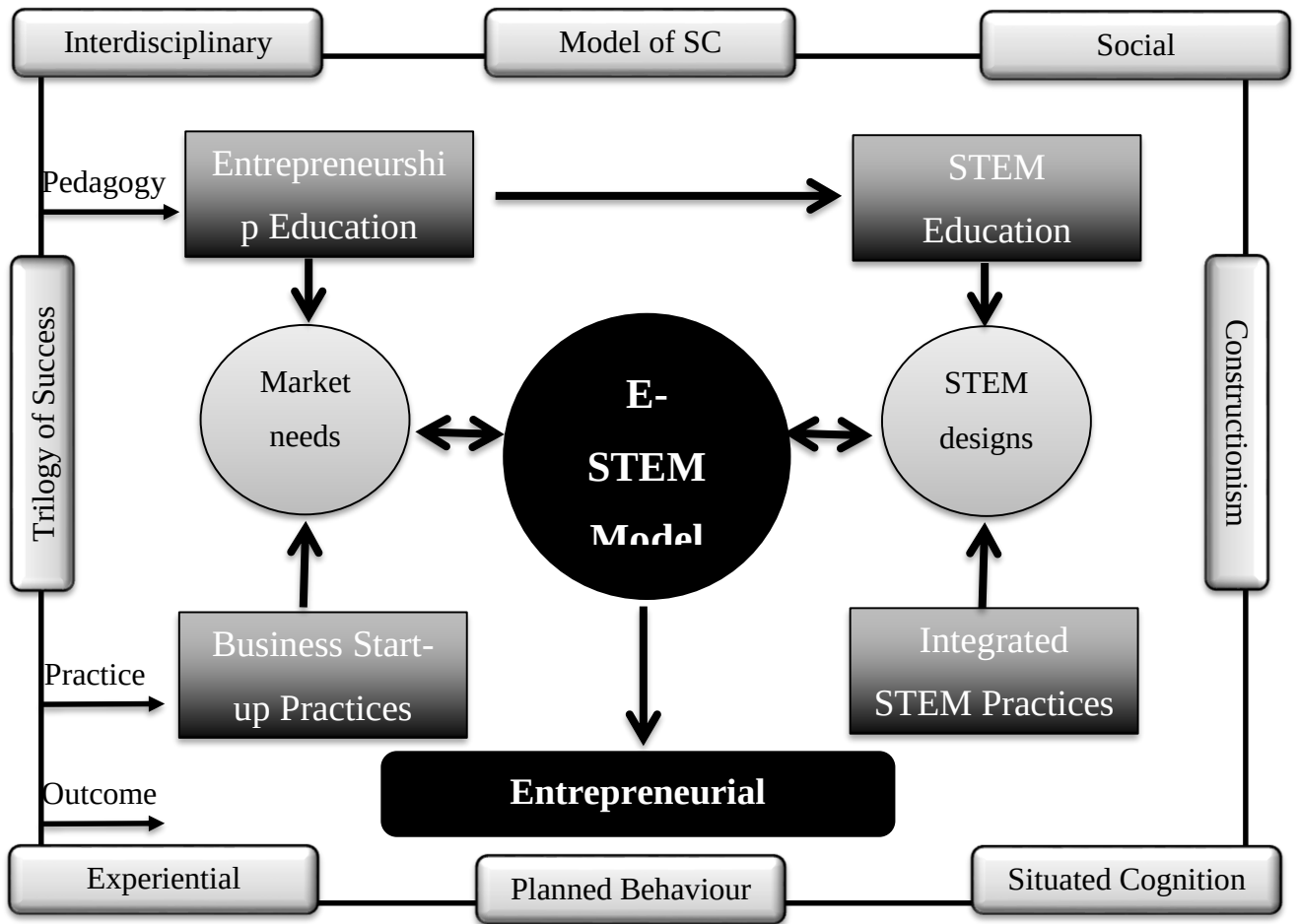


Figure 4: Conceptual Framework of the Study

Figure 4 demonstrates the conceptual framework of the study that is surrounded and supported by a shield of strong theoretical underpinning that guides the path of the study (Adom et al. 2018). Three important elements are taken into consideration. First is the ‘pedagogy’ that refers to the relevant theories and practices that help deliver the academic content to students and indicates the possibility of incorporating entrepreneurial practices into STEM education. Second is the ‘practice’ that refers to how entrepreneurial practices could be integrated into STEM education in the current study in the UAE. Finally, the ‘outcome’ that refers to the development of E-STEM model and the impact of incorporating entrepreneurial practices into

STEM education on the entrepreneurial learning and core competencies of the participating students.

Hence, STEM education is defined as a “standards-based, meta-discipline residing at the school level where all teachers, especially science, technology, engineering, and mathematics (STEM) teachers, teach an integrated approach where discipline- specific content is not divided, but addressed and treated as one dynamic, fluid study” (Merrill, 2009, P.49). Moreover, learning takes place more efficiently through meaningful experiences and reflecting on them, besides nascent entrepreneurs are always learning and action-oriented which concludes that their learning relies better upon going through both educational and real-life experiences (Kydnt & Baert 2013, 2015). Integrating pedagogical methods aims to develop an interdisciplinary model of learning that integrates entrepreneurial practices into STEM education to provide students with authentic learning experiences. The driving force behind developing an E-STEM model in high school is the fact that early learning experiences that emphasize realistic investigation are extremely beneficial in maintaining students’ interest to continue working in the same field in the workplace (Kokkelenberg & Sinha 2010).

In this essence, integrating pedagogical methods seeks to enhance the likeliness that STEM students can be naturally engaged in activities and practices that develop their entrepreneurial passion and mindset by promoting their entrepreneurial competencies. Experiential learning is adopted as the best pedagogical strategy to implement this educational model where STEM practices are applied through project and problem-based learning strategies, while entrepreneurial practices focus on value creation or business-start up strategies in the light of education through entrepreneurship. Accordingly, the proposed incorporation of entrepreneurial practices into STEM education should illustrate how the integrated practices of STEM and entrepreneurship through a situated learning environment can enhance students’ competency profiles containing a reasonable selection of both cognitive and non-cognitive competencies. Therefore, incorporating entrepreneurial practices into STEM education

requires integrating pedagogical methods from both disciplines. Essentially, it needs a relevant combination of teaching and learning practices from STEM education and entrepreneurship courses (Sidhu et al. 2018).

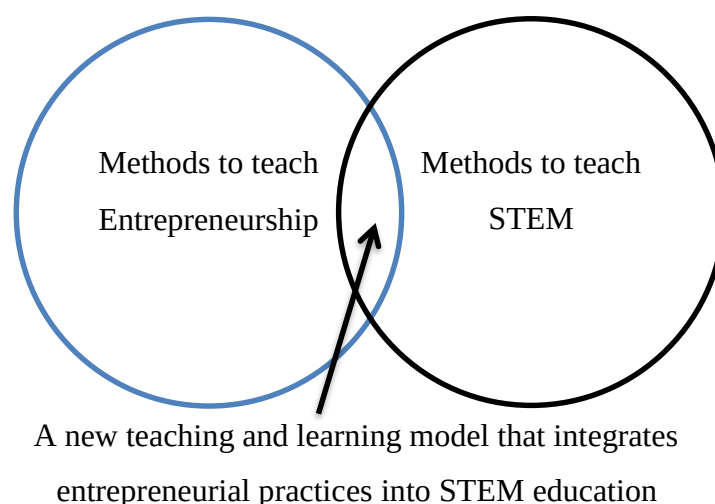


Figure 5: Integrating Pedagogical Methods to Create New Teaching and Learning Model

Figure 5 shows that integrating pedagogical methods from both STEM and entrepreneurial learning will lead to the development of a new teaching and learning model (E-STEM) that incorporate entrepreneurial practices into STEM curriculum. Thus, the aim of this model is to guide STEM educators to incorporate entrepreneurial practices into their teaching instructions in order to close the gap between students' STEM designs and market needs. This will contribute to building a research agenda for both interdisciplinary STEM education and entrepreneurship education. Thus, this inquiry will utilize the available joint potential of STEM disciplines to make learners think and behave in a more entrepreneurial manner. Accordingly, the implementation of interdisciplinary E-STEM practices is highlighted to examine the effect of E-STEM practices on the acquisition of entrepreneurial core competencies of the students.

In this essence, competency-based approach (CBA) is relevant because of the current educational necessity to apply successful pedagogical conditions that enhance students' acquisition of the core competencies that enable them to cope with ever-changing life situations (Dedovets & Rodionov 2015). The literature defined competencies as the main characteristics of individuals that differentiate their performance in a particular role or task (McClelland 1987). Moreover, these competencies involve clusters of knowledge, skills and attitudes that enable people to succeed in life (Davis, Naughton & Rothwell 2004). Therefore, this approach becomes a strategic priority in the educational development because it emphasizes the students' way of thinking. The essence of this approach relies on the philosophy that consistent development of learning skills, knowledge, creative potential and attitudes is more effective than the limited acquisition of knowledge through traditional learning. Accordingly, the learning process will be more meaningful and allow students to become more adaptive and effective in their future careers as well as community life (Knezek et al. 2011). Hence, the goal of many educational researchers is to find a connection between learning and real-life application through utilizing students' learning outcomes outside the school setting. In this regard, CBA prepares students during their learning journey to understand the value of education and classroom practices and how meaningful learning is beneficial to grow competencies that are highly demanded in the workplace. In this sense it would be crucial not to keep the learning outcomes in idle isolation. Instead education should be the foundation for understanding the wider context of life allowing students to solve problems in different scenarios critically.

Dedovets & Rodionov (2015) listed five main principles that allow successful implementation of competency-based approach in education, such as connecting learning phenomena to real life applications, interacting with people like students, teachers, or experts who are experienced and acknowledged to enrich the learning path. Also, performing the main social roles in everyday life, learning to use new technology programs or modern equipment to

facilitate the learning endeavors, and evaluating personal readiness when selecting the educational track in order to develop a sense of direction to the most appropriate job in the workplace for each student. The critical element of competency-based approach is applying active learning strategies in student-centered environment where they can learn independently and achieve better learning outcomes. The most significant result of CBA is the development of the desired core competencies (Khutorskoy 2003). Simply, students should be able to synthesize knowledge, understand connections, use relationships to think and solve real problems. According to the literature, competency-based applications have become increasingly popular methods that are currently utilized for studying many fields such as entrepreneurship education (EE) (Man, Lau & Chan 2002) and STEM education (Dedovets & Rodionov 2015). Under the umbrella of CBA, there are different learning strategies that can be implemented successfully in integrated STEM classes to promote competencies and support the formation of students' learning motives. However, learning by doing, IBL, PjBL (Edmunds et al. 2017), experiential learning process (Ramsgaard & Christensen 2016), interdisciplinary integrated practices and PBL (Tawfik, Trueman & Lorz 2014) are common pedagogical learning strategies that are recommended for both STEM education and entrepreneurial practices (Tan & Frank Ng 2006). This study adopted developing the core entrepreneurial competencies that enhance students' abilities to discover business ideas (Wen Wu 2009) in order to deliver their STEM designs to the market. Instead of placing an emphasis only on teaching the content or developing the skills needed for the workplace in a different setting then hoping the students will realize the connections to real-life situations, the interdisciplinary approach used to implement the integrated E-STEM model seeks not only to locate applicable connections between E-STEM disciplines but also provide a relevant context for learning experiences.

The entrepreneurship researchers focused more intensively on the development of essential competencies that are needed to foster the success of any business. Therefore, understanding

the entrepreneurial competencies is essential to help enhance the process of competency development (Low & MacMillan 1988). In this regard, a set of fourteen entrepreneurial skills was suggested for development through education such as deal making, ambiguity tolerance, networking, opportunity identification, creativity, career assessment, evaluation of the venture created and ethical assessment (Ronstad 1985). Moreover, Garavan & O’Cinneide (1994b) examined six different entrepreneurship education-training programs to identify the common characteristics and objectives of the content of all the programs. Accordingly, they concluded that the consideration of these common elements such as creativity, stress coping mechanisms, skills of reality testing and ambiguity tolerance recognize the complex situations of entrepreneurs. On the other hand, Bird (1988) assumed that team building skills and networking are the most important competencies that identify the successful entrepreneur. Additionally, Hood & Young (1993) contributed to this discussion by summarizing the four primary aspects that should be focussed on to develop entrepreneurial competencies of individuals, which are personality, mentality, content skills and behaviour. Their study explained that entrepreneurship education mainly emphasizes the content knowledge including marketing, financial issues and accounting. While entrepreneurial skills were excluded to human relations, types of communication and leadership abilities. Furthermore, having a vision, creativity and “opportunistic thinking” (Izquierdo, Deschoolmeester & Salazar 2005, p. 4) are classified under the factor of mentality. Finally, they mentioned that personality traits are less likely to be changed because they are usually stable (Hood & Young 1993). Another three factors were recognized as predominant roles in entrepreneurship and emphasized in the literature to develop entrepreneurial competencies, which are entrepreneurial role, managerial role and lastly the technical-functional role (Chandler & Jansen 1992). According to Chandler & Hanks (1994) the entrepreneurial competencies include the ability of students to scan the surrounding environment in order to select and take advantage of potential business opportunities by setting strategies of implementation.

However, marshalling resources and the acquisition of possible useful alternatives is a managerial role that should be mastered as well. The last role is the technical-functional role that gives more attention to technical issues required in certain industry sectors and cannot be emphasized in a general course of entrepreneurship education. Thus, the most recent research studies emphasized the development of the entrepreneurial capacity of the students through promoting three main categories of skills that are entrepreneurship, management and leadership. It also explained that all these skills required applying higher levels of development practices in innovation (Sousa 2018).

The current educational tendencies include the re-conception of content and objectives of education as well as thinking differently of the learning result and its applicability. Since it has been proven that competencies are attainable and learnable through authentic learning experiences as well as consistent practice (Volery, Mueller & von Siemens 2015), the focus of educational paradigms shifted from highlighting qualifications to emphasizing competencies (Salkhanova, Akhmetzhanova, Jalamova & Kakisheva 2015).

There are different opinions on which types of entrepreneurial competencies, educational practices should predominantly focus on (Fayolle & Gailly 2013). Many of the researchers interested in entrepreneurial competencies in the historical literature discussed a short list of characteristics including motivation, creative tendency, risk taking propensity and locus of control (Caird 1993). This narrow view has been used within the enterprise educational field where its feedback is limited to the business owners. In later research, Gasse, Camion, Ghamgui & Tremblay (2006) provided another perspective that has broader view where the focus was given to a list of twelve characteristics. Gasses's list adopted the characteristics of Caird's and added to them action orientation, independence, leadership, need for achievement, opportunity recognition, perseverance, self-efficacy and tolerance to ambiguity. More recently, the literature justified the inclusion of more characteristics to recognize the entrepreneurial individual (Elizabeth, Kaila & Alexandra 2017; Patcharee, Boonnak &

Chatree 2016; Kyndt & Baert 2015; Tsakiridou & Stergiou 2014; Foss & Klein 2012; Hartog, Van Praag & Van Der Sluis 2010). Hence, the literature has widely discussed all the possible entrepreneurial competencies whether they have an empirical support, or they are just theoretical and speculative. However, it was mentioned that not all competencies are needed in all situations (Izquierdo & Deschoolmeester 2005). Thus, educational courses or programs that target the development of entrepreneurial competencies should be selective to a set of competencies that can be emphasized and developed in a certain context.

This study follows the steps of the previous entrepreneurship researchers who adopted the competency approach in studying its educational practices and paid more attention in the aspects that can be developed because enhancing students' entrepreneurial competencies considered to be more essential than providing them with direct knowledge and learning resources (Man et al. 2002). The focus of the current study is given to a range of key competencies from both cognitive and non-cognitive qualities that are essential for producing new entrepreneurs and on the possibility to enhance and develop them via integrating entrepreneurial practices into STEM education (Kyndt & Baert 2015). The study adopted the most relevant definition of competency as a combination of integrated components of skills, attitudes and knowledge that all are relevant to the entrepreneurial context (Kyndt & Baert 2015; Lackeus 2015). The acquisition of these competencies enhances students' abilities and willingness to perform entrepreneurially when creating new value for other people (Sánchez 2011, Burgoyne 1989, Kraiger, Ford & Salas 1993, Fisher et al., 2008). The literature of humanities reflects a positive perspective regarding the possibility of aspiring and supporting a new generation of entrepreneurs, because it has been explained that competencies could be developed through educational practices because they are not innate (Mulder, Lans, Verstegen, Biemans & Meijer 2007; Tsakiridou & Stergiou 2014; Wagener et al. 2010).

2.3 Literature Review

This section delivers a detailed review of the literature regarding infusing entrepreneurial practices into STEM education from different angles to support the study claim. Thus, the main sections introduced in the literature review highlight and discuss the position of STEM education in the UAE, STEM and students' future careers. Thereafter, competencies developed through the implementation of STEM and entrepreneurial work activities that identify the twenty competencies selected to form the student-competency profile, EE and its teaching approaches, the relationship between entrepreneurship and STEM education, and finally the common pedagogical approaches that support both STEM and entrepreneurial learning are discussed.

2.3.1 STEM Education

STEM education refers to integrating knowledge across Science, Technology, Engineering and Mathematics' disciplines (STEM) that are effectively intertwined together to produce innovative designs through a new integrated curriculum. Over the past few decades, slight attention and little integration were given to both engineering and technology subjects (Bybee 2010; Hoachlander & Yanofsky 2011) because the main emphasis was given to promoting only mathematics and science disciplines as isolated subjects (Breiner, Harkness, Johnson & Koehler 2012; Sanders 2009; Wang, Moore, Roehrig & Park 2011). More recently, the integration between STEM disciplines was defined as "an effort to combine some or all of the four disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on connections between the subjects and real-world problems" (Moore et al. 2014, p. 38, cited in Kelley & Knowles 2016). Accordingly, objectives of integrated models based on STEM curriculum can mainly focus the content on one or two of these disciplines. However, the context is for other STEM subject areas (Sanders 2009). Thus,

STEM is considered as a form of an interdisciplinary inquiry that emphasizes teaching meaningful knowledge from integrated subjects in a student-centred environment to solve real-life problems (Capraro, Capraro & Morgan, 2013). Accordingly, areas of STEM content in k-12 classrooms are considered as “collective curriculum” (Roberts 2013, p. 22). However, STEM experiences and practices in high school tend to be passive because a considerable part of the content is presented through lectures rather than modern strategies of teaching. The traditional implementation of teaching instruction comes as a result of teachers’ beliefs’ and professional identity that often influence their acceptance of reforms and its modern applications (Hargreaves 2004). That is why the literature confirmed the need for consistent reform in STEM education (Bayer Corporation 2012).

Despite the fact that real world questions are inherently interdisciplinary, most schools have traditionally separated the main four disciplines of STEM, which confuses the majority of students in recalling the required information from each subject and connecting it to the questions. Many researchers have come to consider STEM as one integrated approach to develop innovative ideas and answer certain research questions that incorporate information from science, technology, mathematics and engineering modules (Bevan et al. 2017). Recently, more disciplines were added to the acronym like arts to become STEAM as a response to supporting innovation and creativity (Land 2013).

Katehi et al. (2009) demonstrated that although the foundation of STEM education lies mainly on the pathway of engineering, it was observed that ‘E’ as one of the four letters that forms the STEM abbreviation is the least utilized and understood during the school stage. That is why; their report recommended that more focus should be given in K-12 to “(a) engineering design [represented in the STEM products]; (b) develop mentally appropriate knowledge and skills for mathematics, science, and technology; and (c) the adoption of engineering habits of mind” (Basham & Marino 2013, p. 9). Accordingly, teachers can employ engineering designs in different contexts such as STEM products, establish

investigations, and participate in a project with a local organization. All these in-depth instructions and investigations help students to become fully engaged in problem-based learning experiences and allow them to recognize the actual relationship between research, STEM product and implementation (Basham & Marino 2013). Hence, STEM education targets the inclination and capability of students to solve authentic problems engaged with STEM related topics in the world (Bybee 2013; Arikan 2018). STEM education seeks to empower more students to help build their countries as global economic leaders and financial pioneers in a time when innovation-based items and technology-based services are viewed as key to development and prosperity (Sievertsen 2016; U.S. Department of Education 2016). Kelley & Knowles (2016) proposed a framework of integrated STEM disciplines by presenting a block and tackle of four different pulleys where each of them represents the common practices used from each of the four STEM disciplines to lift a load. The four main pulleys that represent this framework are scientific inquiry, technological literacy, mathematical thinking and engineering design. Enhancing the integrity of this system requires implementing harmonious practices to tackle its complex relationship. Moreover, it is not necessary to equally integrate all the four domains of STEM contents in all learning experiences. However, it is crucial for teachers to establish a successful level of integration based on the relationship between the domains in this mental model (Kelley & Knowles 2016). Thus, the current study adopted the definition of integrated STEM education by Kelley & Knowles (2016) as an “approach to teaching the STEM content of two or more STEM domains, bound by STEM practices within an authentic context for the purpose of connecting the main four subjects to enhance student learning” (p. 3). This approach is highly recommended in education because its methodology allows students to make use of different types of knowledge to propose significant and concrete solutions to address non-traditional tasks (Dedovets & Rodionov 2015). Moreover, it creates a unique experience that develops students’ personality through shifting the teaching approach from accumulating summary

knowledge to independently using access to diverse resources of knowledge in many contexts outside the traditional learning settings (Knezek, Christensen, & Tyler-Wood 2011). A substantial amount of literature confirmed that problem-based learning and project-based learning strategies are the most successful strategies used in the classroom to enhance meaningful outcomes of STEM education (Edmunds, Arshavsky, Glennie, Charles & Rice 2017; Capraro et al. 2013; Sahin & Top 2015; Wihelm 2014; Lansiquot, Blake, Mark & Dreyfuss 2011; San, Alici & Şen 2018).

Hence, STEM education is an integrated approach that seeks to instil students' acquisition of creative techniques of problem solving and enhancing future innovators' development (Bybee 2010). Generally, the education sector has made a considerable growth in the UAE that relies primarily on knowledge of foreign employees because only 20% of the UAE population is nationals (Al Rostamani 2004, cited in Aswad, Vidican & Samulewicz 2011). Thus, expatriates constitute the majority of the labour market, which is about 91% (Freek 2004). Furthermore, the UAE unemployment rate is expected to trend at 4.9% in 2020 (Trading economics 2017). That is why, it is critical to focus on the development of the intellectual capital of Emirati students in the STEM field to prepare them for the workplace challenges and to facilitate the transformation process (Al Khateeb, Darrat, & Elkhail 2007). Thus, the UAE believed that innovation is driven by continuous improvement that requires curiosity, taking risks and inquiries (MOE 2010). Consequently, UAE educational organizations were asked to implement pedagogical strategies including project and problem-based learning, and STEM projects that support the national innovation agenda (UAE Vision 2021). Moreover, a recent study conducted in the UAE suggested stating an explicit STEM policy as a unified guide for private and public schools in the UAE in order to implement STEM more successfully (Eltanahy 2018). In this regard, Abu Dhabi education announced its move to a unified curriculum in public schools that puts more emphasis on STEM subjects to meet the demand of the UAE labour market (Pennington 2017), which means that students

in grade 11 will no longer be asked to choose between humanities or science streams. Moreover, STEM classes will represent 55% of a students' final grade. However, all private schools in the UAE are also encouraged to encompass STEM practices in their curriculums. The benefits expected for the economic growth of the country in general and for the STEM students in particular is the main driving force behind all the initiatives to enhance STEM education in the UAE (Pennington 2017).

2.3.2 STEM Career through Education

Educators have acknowledged the urgent need to support the reform of STEM education in order to enhance students' acquisition of the skills required for their careers. Developing skills is highly recommended in the workplace for completing any task at appropriate proficiency because these competencies represent the performance domain of the students involving successful application of the relevant knowledge (Jang 2015). Furthermore, it was suggested that extending the learning opportunities that focus on the scientific literacy investigations from school education to include lifelong learning experiences is essential to help prepare students for their future careers (Falk & Needham 2013; Sarkar & Corrigan 2014). For example: the pattern of results of a recent study in the field of STEM education suggested that conveying the content learning to life experiences in different contexts enhance learners' STEM career aspiration (Van, Hoan & Bao 2018).

Furthermore, previous studies conducted in the field of education in the UAE found that high school students are excited in learning scientific concepts through guided inquiry instruction by integrating technology applications (Forawi 2009) to prompt their learning skills. Despite UAE students usually prefer to finish all their education stages before deciding on pursuing a profession. Becoming an engineer or a physician were at the top five preferred future career choices determined by them (Forawi 2014). Thus, it was suggested to enrich students' learning experiences to aspire their choices (Forawi 2014). Thus, a students' career decision

is affected by the learning opportunities of a significant period of learning such as the high school stage (Subotnik 2010). In other words, learning activities in high school are a necessary base that play a particularly key role in guiding STEM students to their desirable careers (Sheldrake 2017). The literature also explained that teaching and learning approaches consistently associate with STEM career aspiration. However, STEM career aspiration is clearly not affected by the solo implementation of a project-based approach (Van, Hoan & Bao 2018). Therefore, students should be exposed to authentic learning experiences through purposeful assignments that provide them with adequate opportunities to use their acquired knowledge and developed skills in their everyday situations. Thus, it is crucial for students to connect their learning outcomes to real job tasks despite being distant to the employment or work responsibilities (Anwari, Yamada, Unno, Saito, Suwarma, Mutakinati & Kumano 2015). Admittedly, future careers do not exist today. Besides, it is difficult to identify their required competencies (Falco 2016). When workplace requirements become higher, it is, however, obvious that the intensity of knowledge and abilities are increased to prepare learners for different career paths either in established organizations or as self-employers. Contemporary theories of motivation argued that student' competency beliefs is a key psychological factor that influence the academic choices of students as well as their desirable careers (Boaler & Dweck 2016). In the accordance of this argument, expectancy-value theory (Eccles, Adler, Futterman, Goff, Kaczala, Meece, & Midgley 1983) assumed that students become more motivated to certain academic disciplines or tasks at which they believe they can achieve and expect their success in applying them. Therefore, launching students to regularly participate in enrichment programs and new STEM models has been found to contribute to their career choices because its practices enhance their skills and confidence to develop a better STEM-scholar identity (Collins 2017). In the light of this discussion, the acquisition of STEM identity as well as the basic entrepreneurial skills can generate new STEM entrepreneurs. Kuratko (2014) identified the entrepreneur as the "one who undertakes

to organize, manage, and assume the risks of a business. Today, an entrepreneur is an innovator or developer who recognizes and seizes opportunities; converts those opportunities into workable/marketable ideas; adds value through time, effort, money or skills; assumes the risks of the competitive marketplace to implement these ideas; and realizes the rewards from these efforts” (p.23).

In a broad sense, the European Commission (2003) suggested that integrating entrepreneurial practices with different disciplines should be a general learning attitude that can be implemented in all school activities to foster students’ entrepreneurial spirit. Educational experiences have a great impact upon students’ interest, ability and competencies, which means that challenging and interactive learning practices in high school can affect their future path in education and workplace as well (Heilbronner 2011). Each student at any stage of life may show an interest to behave entrepreneurially and plan to start new business regardless of their educational background. In this regard, connectedness of students to their future careers or the labour market can be examined by different inquiries (Peña-Calvo, Inda-Caro, Rodriguez-Menendez & Fernandez-Garcia 2016). This study focuses on incorporating entrepreneurial activities to STEM students’ practices. The main idea is to encourage students to practice self-employment by leading or engaging in business activities outside school in order to experience an entrepreneurial work position. Attention is mainly given to the entrepreneurial competencies that can be enhanced through this educational implementation.

2.3.3 Competencies developed through STEM and entrepreneurial Practices

Competencies have been perceived as the aptitude that helps apply a combination of skills and information in a specific professional context (Lans, Verstegen & Mulder 2011). Educational competencies required in the workplace including knowledge, skills and

attitudes are important economic issues because they empower students to successfully compete with their equivalents worldwide. STEM focuses on implementing educational frameworks that guarantee all understudies to move on from secondary education with the essential capabilities and competencies in science, innovation, designing and math. These abilities are basic to enhancing general secondary school graduation and school preparation rates as well as supporting the economic development of the country (Bybee 2010).

Work activities represented in the practices implemented in the learning process for both STEM and entrepreneurship educations have some commonalities that enhance the development of students' core learning competencies. The following table identifies the commonalities of those practices and highlights the suggested competencies that can be developed through consistent implementation based on the literature of both STEM and entrepreneurship fields.

Table 1: Competencies Developed through E-STEM Implementation

Competencies developed through entrepreneurial-STEM implementation			
STEM education		Education through entrepreneurship	
Competencies	STEM practices	Entrepreneurial practices	Competencies
Creativity	Suggest new idea and work to improve performance and produce it	Propose a business initiative	Initiative, pro-activity (Pepin 2012)
Interdisciplinary thinking (Capraro et al. 2013)	Integrate knowledge from science, math, technology and engineering to make an innovative product (Dedovets & Rodionov 2015)	Integrate knowledge from different relevant disciplines with technology to start up a venture enterprise	Information technology (Dedovets & Rodionov 2015)

Planning ability (Elizabeth et al. 2017)	Plan inquiries and adjust the procedures for better outcomes (STEM product)	Make a business plan and take the risk (Hamad, Khan, Shahab, Hameed & Qadeer 2016).	Risk taking, Seeing opportunities (Gürol & Atsan 2006)
Reflective thinking, problem solving,	Synthesize connections between ideas from STEM disciplines and think reflectively to solve any problems	Analyze information, organize resources and evaluate results to choose the best solution, cope and adapt to different situations	Flexibility, insight into the market (Foss & Klein 2012)
Decision making, critical thinking,	Consider the relative materials and benefits of actions to decide the most effective resources (Branes et al. 2014)	Consider the benefits and relative costs to select the most proper one (Hassain, Naser, Zaman & Nuseibeh 2009).	Financial awareness, product functionality
Curiosity, self-knowledge	Search to be updated and use relevant knowledge, attend courses, ask for experts' opinions	Keeping up-to-date technically and applying new knowledge to the job.	Communication skills, networkability
persuasiveness	Find alternative solutions to finish the project that has started (Ronis 2008)	Tolerance to the failure, understand the mistakes and try to overcome it	Tolerance to failure (Tan & Frank Ng 2006)
Innovation (Capraro et al. 2013)	Design a new product (Bevan, Gutwill, Petrich & Wilkinson 2015)	Start new business (Kyndt & Baert 2015) or create new value	Self-efficacy & confidence

Dedovets & Rodionov (2015) explained how STEM education goes beyond the usual learning boundaries of each student. Additionally, its interdisciplinary approach increases the opportunities that enhance students' creative abilities and cognitive skills. Thus, learning STEM helps students to build constructive and valuable knowledge of the features of STEM subjects, as well as an understanding of how this integrated knowledge shape the physical world. Beyond the acquisition of the disciplinary knowledge, STEM education enhances

students' intra-disciplinary skills such as creativity, problem solving and critical thinking skills (Murphy, MacDonald, Danaia & Wang 2018) that all are essential to create new value in order to serve the community in an entrepreneurial endeavour. On the other hand, the implementation of entrepreneurial practices such as making a business plan, collecting and analyzing relevant information, considering the benefits and relative costs and applying alternative solutions to solve unexpected problems, are critical influences that help develop personal competencies of students (Foss & Klein 2012). Research evidence found that personal development is considered as an important factor of motivation that enhances entrepreneurs to proceed (Mitchell 2004). Drawing upon education through entrepreneurship in this study, non-cognitive competencies could be emphasized during incorporating the entrepreneurial practices into STEM education (Moberg, Vestergaard, Fayolle, Redford, Cooney, Singer, Sailer & Filip 2014). While, STEM practices usually give more focus to cognitive innovative skills such as problem solving and critical thinking (Branes, Branes & Dyrenfurth 2014). The current study selected ten competencies from each type (cognitive and non-cognitive) that are known to be associated with enhancing entrepreneurial learning. Hence, the acquisition of these competencies is not solely essential for entrepreneurs, but it is also a powerful indicator of the successful social economic. The holistic emphasis of these competencies is on "the ability to successfully meet complex demands in a particular context" (Mulder et al. 2007, p. 34). However, many educators prefer to perceive competencies that are needed to enhance entrepreneurial behaviour and mindset in a more specific and analytical oriented manner (Chwolka & Raith, 2012; Karlsson & Honig, 2009). The following graph illustrates the selected competencies that could be developed through incorporating entrepreneurial practices into STEM education.

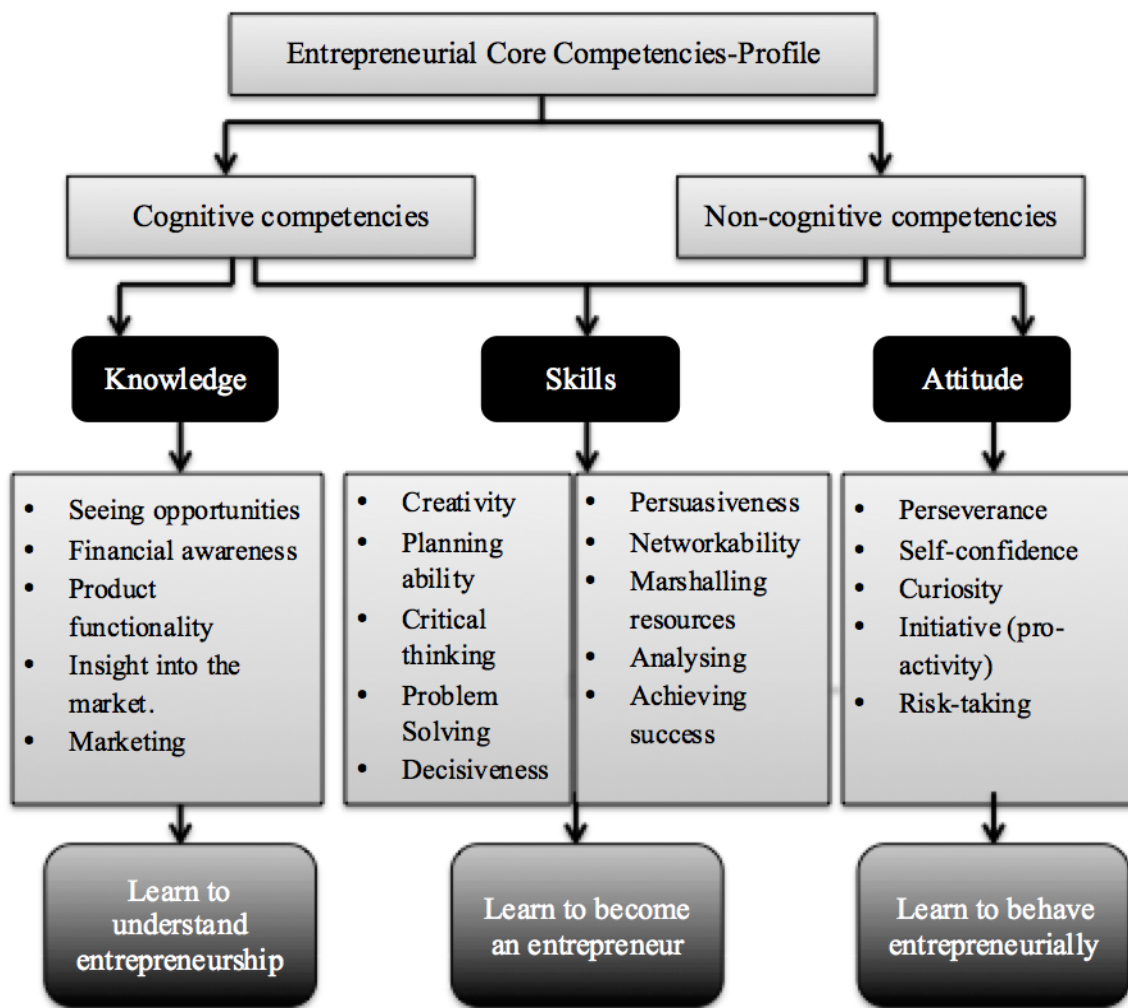


Figure 6: Key Competencies Adopted in the Current Study

Figure 6 introduces twenty entrepreneurial competencies that form the student-competency profile adopted in the current study. Entrepreneurial cognitive competencies are some of the desired results of integrating entrepreneurial practices with other disciplines. Thus, cognitive competencies are considered as the necessary knowledge (Heinonen & Poikkijoki 2006) and the entrepreneurial skills needed for enhancing entrepreneurial initiatives (Hartog et al. 2010). The current study focuses on the basic cognitive competencies such as financial awareness, product functionality, seeing opportunities, insight into the market and marketing. These competencies are crucial to help students develop an awareness of opportunities as

well as constraints about starting up new business (Kyndt & Baert 2015; Tsakiridou & Stergiou 2014).

Developing cognitive competencies is essential in an era that launches the students in the direction of autonomous learning. An intensive body of research confirmed that STEM education enhances many of the students' cognitive competencies that are recognized as fundamental in the labour market such as system thinking, communication, problem solving, adaptability (Koenig 2011 cited in Jang 2015). However, many other competencies such as creativity, innovation, planning ability, problem solving, critical thinking and making reasonable and logical decisions are not exclusively related to entrepreneurial education but they can also be developed through STEM education as well (Elizabeth et al. 2017; Patcharee et al. 2016; Hudson, English, Dawes, King & Baker 2015).

Non-cognitive competencies such as communication and information competencies (Dedovets & Rodionov 2015) are more likely to represent skills and attitudes of the students. There is an emerging body of studies that asserts the critical role of non-cognitive skills in predicting the outcomes of the market (Cunha & Heckman 2008; Heckman, Pinto & Savelyev 2013). Moreover, Heinonen & Poikkijoki (2006) listed competencies such as pro-activity, initiative, independence, self-confidence, curiosity and persistence under the category of attitudes. In addition to risk taking and the need for success that are considered as the most frequent characteristics of an entrepreneur (Gürol & Atsan 2006). The non-cognitive competencies also include essential skills such as persuasiveness, social orientation, marshalling of resources (Foss & Klein 2012) in order to facilitate turning students' creative ideas into action (Huber 2015). When identifying which specific aptitudes are seen critical for new entrepreneurs regardless of their sectors, competencies like having insight into the market and perseverance were considered a positive indicator to perform

entrepreneurial behaviour and to become and remain an active entrepreneur in the future (Kyndt & Baert 2015).

Success is driven by the acquisition of the most relevant and appropriate knowledge, having as many experiences as possible to master the desirable skills and developing a positive attitude to proceed and overcome barriers (Tshikovhi & Shambare 2015). Therefore, the following paragraphs discuss the selected twenty-inclusive competency set (derived from Kyndt & Baert 2015) that includes cognitively and non-cognitively oriented competencies. Many of these competencies can be generally developed in the context of STEM education and all specifically in entrepreneurial practices. Thus, STEM students are more likely able to acquire these competencies through applying and practicing the knowledge they learn in the educational setting of the entrepreneurial-STEM model.

2.3.3.1 Entrepreneurial Knowledge

Entrepreneurial knowledge refers to “an individual’s appreciation of the concepts, skills and mentality expected of an entrepreneur” (Jack & Anderson, 1999, p. 118). It is also perceived as the necessary information and useful experiences that have been learnt and successfully gained during carrying out an entrepreneurial activity in business. Moreover, it was articulated that the consistent exposure to entrepreneurial practices help foster the acquisition and the development of this knowledge (Massad & Tucker 2009). Thus, the role of the education system is to simplify activities that are perceived and supposed to be beyond students’ capabilities in order to increase high school students’ confidence and beliefs in their own knowledge and abilities as well.

Seeing opportunities is the ability to recognize and seize suitable opportunities attached to the entrepreneurial process (Rae 2007). This knowledge can be taught in the educational setting not only to establish new business but also to develop entrepreneurial habits of mind

that are required in the real working environment. Thus, this competency is related to seeking market opportunities through identifying and assessing them (Man, Lau & Chan 2002). In STEM education, students can develop this process more effectively provided that they often collaborate with partners to discuss the pros and cons of each opportunity (Hill 2016). The process of opportunity recognition was described in the literature as “connecting the dots” (Baron 2006, p. 108) where learners are trained to establish a pattern of cognition till it becomes a habitual process in which the pattern can be easily repeated in different contexts.

Financial awareness refers to the ability of students to realize the average cost of their projects and to understand how to keep the final cost of what they are doing under control. A basic understanding of financial facts is required to enhance students’ consciousness of all forms of expenditure during conducting their educational project as well as creating new business (Rezaei- Zadeh et al., 2014). Accordingly, education plays a vital role to empower students with adequate knowledge and skills to manage their money in order to be able to identify the required budget and to take informed financial decisions. Thus, incorporating entrepreneurial tasks into STEM lessons is considered as a practical activity to develop learners’ financial skills in order to manage their fund and to plan for every purchase in order to keep the cost of their requirements as low as possible (Man, Lau & Chan 2002).

Product functionality is a cognitive entrepreneurial competency that refers to the overall ability or the function of the product or design made by students. It also refers to how each product facilitates users’ tasks and addresses their needs (Tsakiridou & Stergiou 2014). Learning and applying this competency will help STEM students to identify the need of their designs and enhance their awareness of developing a meaningful purpose of their work instead of depleting their learning time for making products that are not needed for any users in the market. Additionally, they will be able to identify the target customers of their products. One of the desirable outcomes that is expected from crossing the boundaries

between entrepreneurship and STEM is promoting students' design thinking and their entrepreneurial attention as well. Thus, the thinking disposition of functional design is valued both within and beyond entrepreneurship; it strengthens the connection between STEM and entrepreneurial practices that are the core constituents of the 21st century education.

Having insight into certain target market refers to a students' ability to assess any possible risks in order to be ready to overcome them. This ability can be developed through many steps that are all closely related to the students' orientation towards learning. Starting by identifying the equivalent products that have been delivered to the market to provide customers with the same service (Kydnt & Baert 2015). In this essence, students should identify the target audience that represent their customers and know what they are passionate about. The need to evolve the market and search to identify the current competitors is useful to make novel entrepreneurs remain up to date with the newest developments (Wagener, Gorgievski & Rijdsdijk 2010). Ultimately, students should use, understand and analyze all the collected information to reduce the potential risks to the business opportunity.

Marketing refers to the ability of students to introduce their products or services to the market. Getting the word out about the value you are trying to create or the business you are developing can be achieved through many channels such as networking or online media, posters in or outside school, brochures, newsletters and emails. Furthermore, students should be aware of where they can find their customers in order to introduce their service or sell their STEM products to gain profits. Hence, marketing is regarded as "the management process of identifying and satisfying the requirements of consumers and society in a sustainable way" (Evans 1995, p. 4). Entrepreneurial learning seeks to enhance the philosophy of this holistic management process among students in order to improve effectiveness through focusing on the satisfaction of target consumers' desires (Foskett, 2002).

2.3.3.2 Entrepreneurial Skills

Identifying instructive competencies for the current work environment is driven by the urgent need to alleviate variances between objectives of the learning process in the educational setting and the necessities of the work market (Jamaludin & Hung 2017). Therefore, a large variety of skills have been recognized in the entrepreneurship literature as being essential to apply and incorporate entrepreneurial practices into education (Laguía, Moriano & Gorgievski 2019). Integrating these practices with STEM education can help students identify logical evidences that lead to formulating reasonable conclusions during their learning. Notably, STEM-related skills are progressively relevant to other fields, and not exclusively identified with STEM disciplines. As, the framework of NGSS (2013) clarified, “learning about science and engineering involves integration of the knowledge of scientific explanations (i.e., content knowledge) and the practices needed to engage in scientific inquiry and engineering design. Thus, the framework seeks to illustrate how knowledge and practice must be intertwined in designing learning experiences in K-12 science education.” (NRC 2012, p.11).

The current study highlighted ten entrepreneurial skills that are essential for both STEM education and entrepreneurial learning. The first five competencies are more likely to be considered as cognitive-oriented competencies, which can be successfully developed in the educational setting, while the second five skills are characterized as non-cognitive competencies in the literature, which are usually developed more effectively via real life communication (Dedovets & Rodionov 2015; Krueger & Sussan 2017).

Creativity is the ability to imagine and think of new, useful and valuable ideas. This cognitive skill is vital to design innovative products in the STEM class (Sternberg 2001). Accordingly, teachers are asked to learn how to integrate creativity in their teaching and learning

instructions; it is highly relevant to problem solving strategy that is recommended for effective STEM implementation (Sternberg 2007). Although it is difficult for teachers to teach creativity as a separate topic, it is still possible for them to plan and facilitate the learning process in order to support their students to practice thinking in a creative way (Dewey 1934). An educational report suggested that STEM programs in schools should adopt engineering "habits of mind" (Katehi Pearson & Feder 2009, p.5) that involve creativity as a basic element to be achieved. Additionally, numerous studies have been explained that creativity is necessary to become an entrepreneur (Foss & Klein, 2012; Kirzner, 1997; McGee, Peterson, Mueller & Sequeira 2009) who has developed an entrepreneurial passion that is required to explore and identify the most suitable business opportunities (Moberg et al. 2014; Laguía, Moriano & Gorgievski 2019).

Planning is a cognitive skill referring to the ability of students to structure a certain task. Hence, problem-based learning is the best strategy to be utilized in STEM education where students work on complex as well as ill-structured problems to enhance their cognitive development (Capraro, Capraro, & Morgan, 2013). Planning is an essential practice that allows students to think ahead in the light of specific vision to reduce expected risks (Kydnt & Baert 2015). Accordingly, this ability is not only needed to solve STEM problems in a learning inquiry environment but also to establish a causal link towards starting a new business (Honig 2004) because it allows students to organize, analyze, evaluate data and make judgments regarding weaknesses and strengths of the work done. This ability is highly linked to resource skills that allow students to secure access to the required resources as well as to strategic skills that help them setting priorities and focusing on goals (Fisher, Graham & Campeau 2008). It was mentioned in the literature of entrepreneurship education that learning the basic marketing skills is important to make young students excited about conducting and contributing to an entrepreneurial project appropriate to their learning stage

(Lackeus 2015). The main objective of developing this competency via this study is to encourage STEM students to practice creating and designing an appropriate business plan that depicts the necessary procedures to start a business (Tsakiridou & Stergiou 2014).

Critical thinking is a cognitive skill (Harvey 2018) that is defined as “the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action” (Scriven & Paul, 2007, p. 1). During working on STEM content or problem, students develop this mode of thinking whilst attempting to acquire better critical thinking disposition by applying the intellectual standards of reasoning (Forawi 2016). Arguments found in the literature refer to the difficulty of teaching critical thinking and suggest applying integrated approaches to enhance the cognitive development of students (Capraro et al. 2013). Neck & Greene (2011) argued that entrepreneurship as an applied discipline gives entrepreneurs the opportunity to think and act like designers, requiring many cognitive skills such as critical thinking, creativity and problem solving. Moreover, it was noted that tools of design thinking could be utilized in many disciplines such as entrepreneurship as well as education (Brown 2009). From this it is evident that infusing entrepreneurial practices into STEM education can enhance students’ critical capabilities (Aslam et al. 2014).

Problem solving is the ability to use all available methods to overcome certain challenge through identifying the problem, generating alternatives and evaluating them, then finally implementing the best possible solution (Muir, Beswick & Williamson 2008). Anchored and practical instructions that are guided by project-based science and problem-based learning are the main pedagogical methods utilized in schools to develop students’ problem-solving abilities (Cooper & Heaverlo 2013). Thus, the ability to solve ill-structured challenges is considered as a crucial competency for STEM learning (Jamaludin & Hung 2017) where

students usually face unknown elements or unexpected issues and should be able to address them with a good degree of confidence. The experience of applications is as important as the theoretical knowledge for facing a complex situation in real-life. Therefore, producing the correct and effective educational model that provides more authentic practices for school students to better implement problem solving skills is highly required to enhance their cognitive development (Kitchner 1983; Kirkman 2017).

Decisiveness refers to students' cognitive ability to make reasonable decisions, which is a necessary asset for STEM students as well as entrepreneurs. Making clear-cut decisions should rely on deep search via a variety of information resources in order to draw rational assumptions (Rezaei-Zadeh, Hogan, O'Reilly, Cleary & Murphy 2014). When consequences or results are not fully predictable, successful conclusions that lead to right and logical decisions are not only supported by eliciting information independently but also require experts', consultants' and colleagues' advices whom have deep insights and meaningful experiences that allow them to offer important recommendations (Kydnt & Baert 2015).

The following entrepreneurial skills with less cognitive characteristics (more non-cognitive) are usually interconnected with students' mindset (Menke 2018). Additionally, they are also affected by students' inquisitiveness, sociability and adaptability. Literature of personality traits categorized them as agreeableness and openness, all of which can be taught and enhanced in the educational setting (Moberg et al. 2014).

Persuasiveness is a non-cognitive skill that refers to students' ability to convince others to accept their desired way of thinking, which requires applying the contextual standards of public speaking (Oreg & Sverdlik 2013). In order to develop such a communication competency, it is crucial to define and identify certain communication objectives that are needed as well as the possible communication methods during the learning process. Dedovets

& Rodionov (2015) explained that communication competencies could be successfully acquired via STEM education where students often work independently to prepare a presentation plan in order to display their knowledge, evidences and decisions taken and to describe the obtained results during their STEM projects or products in an effective persuasive argument. Furthermore, this competency supports students to participate in-group discussions and to add value during any oral and written piece of work. More importantly, it is beneficial when negotiating with others around financial expenses and facilities. Accordingly, this perceived ability is strongly attached to students' academic self-efficacy, which is extremely critical (Wang & Neihart 2015).

Networkability is a non-cognitive skill that refers to the social scaffolding dimension internal and external to the educational setting. On one hand, students can assist and support each other in school through working on an inspirational-social environment to solve authentic problems in education (Gutwill & Allen, 2010; Pea, 2009; Zimmerman, Reeve & Bell 2010). On the other hand, it refers to the effective relationships with adults outside the school atmosphere that can support students to persist and create new channels to serve the learning process. Students demonstrate networkability in STEM classes by discussing ideas and offering advice or solutions while working on the same project, which leads to better learning experiences (Bevan et al. 2014). Building a network of assistance is a key attribute for any successful entrepreneur (Menke 2018) in order to be provided with a consistent facilitative and collaborative support to reach the learning goals (Moberg et al. 2014). Thus, this process requires retaining peers and recruiting useful people through internal and external-robust relationships to strengthen the network (Man et al. 2002) Most entrepreneurial initiatives require a strong team and good social communications to be performed (Davidsson & Honig 2003).

Marshalling resources is a non-cognitive skill, which refers to the ability of students to identify, gather and reasonably organize different resources in order to exploit the best opportunities for starting-up new business (Moberg 2014). It was observed that social capital plays a strong role in this process, which reflects the casual link between networkability and marshalling resources (Karlsson & Honig 2009). This long process helps students experience managing ambiguity in order to implement their ideas. The literature of applied science advocated that STEM learning is a multifaceted process that allows students to exploit as ubiquitous resources as possible, such as human resources that require communication tools. Other resources that rely on information technology and tools, such as print-base resources (printers, copiers, fax, etc.), and media or digital resources (TV, smartphones and computers, video recording, internet, electronic mail, etc.), are all valuable to search and select necessary information (Dedovets & Rodionov 2015). Utilizing all these resources allows students to expand upon the classroom experiences and get access to reliable knowledge and advice from content- expertise (Hora & Oleson 2017). Consistent use of information resources will enhance students' ability to search, convert and transfer knowledge into their application. Furthermore, the entrepreneurship literature asserted that entrepreneurial practices often take place in a context that is characterized by ambiguity and pertained to uncertainty. However, it is difficult to teach how to marshal all types of resources and manage the ambiguity of its context. Accordingly, this skill is categorized as an interrelated- entrepreneurial skill that can be acquired and successfully developed through hands-on authentic and learning experiences and consistent practice to be learnt (Moberg 2014).

Analysing data is perceived as the ability to evaluate information in both inductive and deductive methods. Tsakiridou & Stergiou (2014) explained that students who discuss and work together to assess complex situations to make well-balanced choices develop their analytical skills. Thus, the acquisition of these skills requires practices that allow students to

collect and visualize data to understand the meaning behind certain facts. Moreover, it could also be the ability to deconstruct information of complex problems or situations to verify the roots behind this challenge and identify its details. This requires the use of all the possible analytical tools such as graphs, tables and previous models that help understand the expected consequences of any decision. Generally, working in collaborative groups is the best way to strengthen and develop this competency where students usually work on analysis-based projects such as designing STEM products to achieve the desirable learning goal.

Attaining personal success relies on the potential need of an individual to become an achiever, which is a non-cognitive competency that is seen as a skill as well as an attitude. Therefore, the need for achievement is defined as the individuals' desire to do their best in order to achieve an internal sentiment of accomplishment (Tsakiridou & Stergiou 2014). A number of key scholars explained that achieving success is usually associated with narcissistic perceptions of entrepreneurs where their self-belief is based on the underlying desire to achieve the required end goals and the ability to recognize the potential challenges that may accompany it (McClelland 1987; Perry, Macarthur, Meredith & Cunningham 1986; Klyver, Hindle & Schøtt. 2007). However, the literature of education has not clarified precisely the extent to which this need for success should exist. Thus, developing entrepreneurial competencies within STEM students is an achievement because they usually strive for that level.

2.3.3.3 Entrepreneurial Attitude

All the following competencies related to entrepreneurial attitude, revolve around students' beliefs on their ability to perform a task and face its challenging obstacles. Moreover, researchers of personality attributes categorized these non-cognitive competencies as

conscientiousness of individuals (Bengtson 2013). A key element of these competencies is that they are not static like inherited traits, which means that they can be taught, fostered and developed and adopted through educational practices. It was found that entrepreneurial attitude is positively associated to entrepreneurial activities (Draghici, Albulescu & Tamasila 2014). Therefore, the acquisition of these entrepreneurial competencies is the key driver of entrepreneurial success (Rașcă & Deaconu 2018).

Hence, perseverance is the process of being persistent when doing a task despite difficulties or challenges that might delay achieving the required objectives (Eisenberger 1992). Being perseverant is strongly attached to students' self-efficacy that reflects their beliefs towards their abilities to achieve complicated tasks and to deal in a flexible way with changing and vague situations (Scherer & Gustafsson 2015). In other words, it is the extent to which students are capable of overcoming adverse circumstances and remain vigorously determined to meet objectives (Markman, Baron & Balkin 2005). Moreover, there is no doubt that successful STEM students strive to complete their tasks, projects and/or designs though they are tired of its procedures. Thus, educational practices should be manipulated in a way that help students develop this strong entrepreneurial attitude to remain steadfast in the face of any adversities, which is also an essential competency to enhance their entrepreneurial resilience (Harris 1994). Furthermore, incorporating entrepreneurial practices into STEM education requires a persistent effort from students to examine their prior knowledge and proposed hypothesizes in order to successfully design STEM product and be able to deliver it to the market. Therefore, El-Gohary, O'Leary & Radway (2012) clarified that students' tolerance to ambiguity and their ability to cope with uncertainty and to continue working to achieve the objectives despite constraints or setbacks is one of the key competencies (Duhamel 2016) that should be promoted during the learning process (Tsakiridou & Stergiou 2014) to develop an entrepreneurial mindset (Naumann 2017).

Self-confidence is a competency referring to students' belief in their ability to successfully achieve the task (Fisher et al. 2008). Students with high self-confidence and self-efficacy are more independent and often remain committed to their vision and proud of the learning process they went through, and that not only can make them more open to surprises, but also help them to adopt with its challenges (Sanchez 2011; Murnieks 2007). Thus, being independent is an attitude that allows you to successfully work as an individual or as an active member in a team, which constitutes the basis of all other entrepreneurial aspects. Furthermore, students who are viewed as independent learners usually elicit trust and take serious responsibility towards their actions and decisions (Wagener et al., 2010). Actually, Bandura (1994) explains that this competency cultivated throughout life and schools play a crucial role in its development, which means that learning can help develop students' confidence and justify self-efficacy in order to be able to work in stressful situations and to effectively deal with goal setting. It was also found that engaging students in scientific activities with accessible learning resources might have the potential to promote their self-confidence (Tsai, Li & Cheng 2017). Accordingly, students' confidence in their own capabilities could enhance their willingness to pursue and explore entrepreneurial opportunities (Tsakiridou & Stergiou 2014).

Curiosity or being learning-oriented is a non- cognitive competency that refers to the strong desire of students to learn about certain topics, which make them elicit, understand and acquire the required knowledge independently, and apply the new knowledge in a different practice to solve its authentic problem. Satisfying your learning curiosity is not a simple process because it requires you to become a highly learning-oriented person who consistently searches for useful knowledge and enhances his /her skills to develop the overall performance. Moreover, curiosity launches students in the direction of being involved in new development activities and methods in order to be provided by recent knowledge that is

relevant to their interest (Lans, Hulsink, Baert, & Mulder, 2008). Acquiring information competencies and the ability to use the information competently is perceived as an integral part of students' personal qualities (Dedovets & Rodionov 2015), which has been proven to be successful in the development of the learning process. Both students' motivation to learn and their ability to derive knowledge are highly connected to their abilities of marshalling different resources in order to perform informational activities.

Furthermore, the sense of taking initiative and being a proactive individual refers to students' ability to turn their ideas into action and to tackle unexpected problems (Pepin 2012). Having a proactive personality and an action-oriented mindset is highly required. It is not only for effective STEM students because it is an indicator for their future performance in the workplace (Rodrigues & Rebelo 2013), but also for developing students' entrepreneurial attitude towards setting clear targets and doing relevant action plans (Guimarães 2017). Action orientation is increasingly acknowledged by entrepreneurship researchers as an essential ability that is strongly connected to the ability to recognize business opportunities, because having an idea without doing any form of action leads to unanswered opportunity (Tsakiridou & Stergiou 2014).

Risk-taking is a competency referring to the propensity and the ability of students to take new risks and persist in intellectualism. STEM education as a creative process of inquiry encourages the approach of learning by doing through what is called "STEM rich-making activities" (Bevan, Ryoo & Shea 2017, p.1). This process is challenging at the school level as well as rewarding because STEM students are allowed to take risks to develop their ideas and make their own designs or products under the supervision of the program staff. Thus, it is a great opportunity for high school students to develop this competency to be able to recognize the probability factor within their decision and to deal more effectively with possible consequences (Kydnt & Baert 2015). In economic life, the absolute certainty of

predicted outcomes of any project is not guaranteed, which explains why the ability of taking risks is inherent to entrepreneurship and is highly required to enhance students' entrepreneurial attitude and foster their entrepreneurial mindset (Macko & Tyszka 2009). It is well known that the only trait that differentiates the job seeker from the job maker is the probability of taking risks or coping with uncertainty by the latter (Entrialgo, Fernanderz & Vazquez 2001). Thus, the desire to create and to achieve success as well as match the intensity to bear expected risks creates new room for students to experience new field like the market. Experiential practices help students to gradually manage future risk issues that might arise for entrepreneurs (Malach & Malach 2018).

2.3.4 Entrepreneurship education

Due to a constant change in economy, stability of employment is no longer guaranteed, and it should not be perceived as linear any longer. That is why it is necessary that schools provide students (as the future workforce of the community) the learning opportunities to develop the essential entrepreneurial competencies to cope with the challenges of the work context (Costa, Caetano & Santos 2016). There has been a great emphasis in recent years regarding enhancing entrepreneurship education in the UAE (Bradstreet & Dun 2013) because it is being recognized as an essential tool to create new job opportunities and economic independence for youth. Therefore, education was called for action because it is a prerequisite for enhancing entrepreneurial initiatives that help raising productivity in all economic zones (Hamad et al. 2016). Moreover, EE is a critical instrument often considered in the development of the policy framework, and its outcomes can be analysed to enhance curriculum development (Ansari, Bell, Iyer, & Schlesinger 2014).

Learning is defined as the process of constructing knowledge through authentic experiences, where the acquisition of this content knowledge and skills can guide students' future behaviour. Thus, students' entrepreneurial motivation is strongly affected by the learning

entrepreneurship course (Jakarta 2019). Basically, there are unlimited strategies that enable education to respond quickly to the important requirements of any productive sector. That is why the World Economic Forum (2014) believed that creating a conducive ecosystem is highly supported by successful educational contributions. Peter Drucker is one of the major thinkers in America who explored the area of innovation and entrepreneurship in terms of the essential practices - he explained that entrepreneurship is neither mysterious nor magic and it is not inherited but it can be taught and learned (Drucker 1985). Besides, its changeable skills can also be taught and developed via entrepreneurial practices (Oodterbeek, Praag and Ijsselstein 2010). Having said that academic courses in education are seen as an essential element that affects students' entrepreneurial intent (Sanchez 2011).

Hallam, Leffel & Calvoz (2015) believed that identifying the entrepreneurial potential of the students as early as possible critically influences the economic success. Thus, entrepreneurship as a force that impacts the economic situation of any country should not be underestimated. In addition to this point, there is a consensus that entrepreneurship can be taught (Gutierrez & Baquero 2016; Rae 2014). Moreover, the literature of entrepreneurship education found that the acquisition of entrepreneurial competencies is not significantly related to students' demographic characteristics such as gender (Kumara & Kumar 2010). More importantly, practice to implement a positive approach toward challenges can turn them into entrepreneurial learning (Funken, Gielnik & Foo 2018). Therefore, emphasis is placed on the responsibility of the educational sector in generating more entrepreneurs (Heidi & Karen 2014). Hence, EE is mainly considered as a stand-alone subject that is usually offered as an elective course to learners in business related studies. Diffusing entrepreneurial activities to be accessible to all students of different streams is a real challenge that requires an interdisciplinary approach to raise students' awareness of entrepreneurship and to develop their abilities (Wilson, 2008). There is an on-going discussion in the entrepreneurship literature about how to incorporate entrepreneurial applications into existing course

framework because it acts as a catalyst for the economic growth (Heidi & Karen 2014). In other words, “Interdisciplinarity” (Oganisjana, Keke, Rahman, Fernate & Rutka 2014, p. 451) of the basic entrepreneurial practices is recommended (Gibb 2002) through shifting the paradigm of teaching entrepreneurship as a separate discipline to integrating entrepreneurial practices with different disciplines to enhance the entrepreneurial mindset of learners (Oganisjana et al. 2014). Therefore, this study aims to develop a pedagogical strategy in the light of interdisciplinary learning to promote entrepreneurial competencies among STEM students.

Heinonen and Poikkijoki (2006) limited the aim of the entrepreneurial activities at increasing students’ knowledge about entrepreneurship in order to develop an enterprise. Afterwards, the European Commission (2012) expanded this narrow view to a broader statement to define entrepreneurship education as “a process through which learners acquire a broad set of competencies which can bring greater individual, social and economic benefits since the competencies acquired lend themselves to application in every aspect of people’s lives” (p. 7). The current study adopted this definition that reflects the multiple objectives of conducting entrepreneurial practices, for example, it offers training and guidance of how to plan for business start-up. Although the corporation of entrepreneurial practices in education is a critical challenge for teachers, it enhances students’ entrepreneurial mindset through developing a set of lifelong entrepreneurial skills (Kuratko & Morris 2018).

The literature introduces a set of entrepreneurship terminologies that all have been used in publications related to the sector of education. Thus, the concept ‘entrepreneurship education’ refers to the process of learning how to become a self-employed person through setting-up a venture. While, ‘enterprise education’ refers to the learning process of entrepreneurship that broadly gives more attention to the development of students ‘mindset,

attitudes, skills, abilities and personalities (QAA, 2012), such as whether they were able to run their own actual business or were just working on the process of planning to start a new one. In the United Kingdom, ‘entrepreneurship education’ and ‘enterprise education’ are the most frequent concepts used in publications, whereas only the former term is often used in the United States, which causes misunderstanding. That is why, the term entrepreneurial education was proposed as a unifying concept that encompasses both the previous definitions including entrepreneurial learning and practices that lead to the development of students’ entrepreneurial competencies (Erkkilä, 2000). To avoid confusion as well as to focus on the objectives of this inquiry, the term ‘entrepreneurial practices’ is used extensively in this study to refer to all the educational practices needed to create new value or to start up new business. Implications of a recent study in entrepreneurial learning suggested implementing pedagogical approaches that are more competence-oriented than knowledge-oriented to develop students’ entrepreneurial competencies (Biberhofer, Lintner, Bernhart & Rieckmann 2018). Furthermore, students’ acquisition of entrepreneurial knowledge tactics is one of the important consequences of entrepreneurial learning experiences, while the number of entrepreneurial competencies is numerous, and the nature of the entrepreneurial project affects the development of a selected set of these competencies according to the activities applied (Djilali & Boucha 2018).

2.3.5 Teaching approaches of entrepreneurship education

Considerable discussion has been found in the literature regarding the ability to teach entrepreneurship, however, the debate was closed by a consensus of agreement on the possibility of teaching and learning its features (Henry, Hill & Leitch 2005a, 2005b). Educating students to become entrepreneurs is different from educating them on how to act entrepreneurially (Jones & Iredale 2010). Thus, most recently, however, the new debate has focused on the most appropriate methodology of teaching entrepreneurship to each grade

level, which results in a call for a re-evaluation of the current pedagogy to emphasize teaching through an approach that works on students' abilities (Jackson, Scott & Schwagler 2015). The diversity of the approaches used across the world to apply entrepreneurial programs does not cause a conflict provided that they include business basic and focus on entrepreneurial thinking and competencies such as problem solving and opportunity recognition (Neck & Greene 2011). Accordingly, one of the core questions in the field of entrepreneurship is how entrepreneurial behavior and competencies can be taught or developed in education (Acs & Audretsch 2010). In this essence, researchers of entrepreneurship differentiated the approaches of teaching entrepreneurial education based on the learning goals of the organization where the curriculum and its assessment are also influenced by these goals (Deuchar, 2004; Pepin, 2012). Thus, entrepreneurship education has mainly focused on the content knowledge of entrepreneurship that launches the students in the direction of being entrepreneurs who are able to establish a new venture enterprise (Katz 2008) in the tertiary level because students can communicate more closely with the labour market (Rosendahl-Huber, Sloof, & Van Praag, 2012 cited in Moberg 2014). The primary focus of EE is shifted from content to pedagogy in the lower levels of education to develop students' entrepreneurial skills (Pepin 2012) because it is not easy for lower secondary students to convey the entrepreneurship content to the market.

Two leaders in the field of entrepreneurial pedagogy emphasized, "the analytical approach of teaching opportunity evaluation, feasibility analysis, business planning and financial forecasting is the cornerstone for most entrepreneurship curricula today" (Nick & Greene 2011, p. 57). However, many scholars within this field strongly argued that structuring the learning process is the most effective method to enhance the entrepreneurial characteristics of the students (Hannon 2006; Kearney 1999). The argument revolves around whether the attention should be given to the content knowledge or pedagogical knowledge (Jones &

Iredale 2010) that is whether the emphasis should be on ‘education for entrepreneurship or education through entrepreneurship’ (Hannon, 2005). Therefore, the extent to which students are close to the workplace is an important factor that should be considered while selecting the appropriate teaching approach of entrepreneurial education.

Table 2: Differences between Education for and through Entrepreneurship

Differentiated Elements	Education for Entrepreneurship	Education through Entrepreneurship
Perspective	Content-oriented perspective	Pedagogy-oriented perspective (Jones & Iredale 2010)
Purpose	Enrich declarative knowledge (Larson 2000)	Creates authentic and relevant learning experience
Focus (Katz 2008)	The profession and knowledge about venture creation	Personal development and entrepreneurial competencies
Curriculum	Entrepreneurship knowledge is offered as a separate school topic or subject	Method embedded in other topics or through interdisciplinary learning (Johannisson 2010)
Outcomes	Knowledge about how to start a venture and how to make a business plan (Cunha & Heckman 2010)	Social and character qualities ‘attentiveness, sociability, self-esteem, perseverance, motivation & forward thinking behavior’
Teaching method	Lecture-based education (Mwasalwiba 2010)	Practice-based education
Foster	Cognitive entrepreneurial skills	Non-cognitive entrepreneurial skills
Enhance (Moberg 2014)	Negative engagement of students in the learning process	Positive engagement of students in the learning process

Table 2 differentiates the two approaches of entrepreneurship education according to Moberg (2014). The first approach reflects the possibility of teaching entrepreneurship in isolation as an educational discipline, while the second approach emphasizes integrating the entrepreneurial practices in order to promote entrepreneurial initiatives through developing

students' competencies. The proponents of education for entrepreneurship have a content-oriented perspective, which encourages education to introduce entrepreneurship to students in higher education to motivate them to consider a career as self-employed which requires teaching this field in a separate subject. On the other hand, the pedagogy-oriented perspective is usually for the proponents of education through entrepreneurship (Johannisson 2010) where the focus is mainly on developing the core entrepreneurial competencies of the students (Mahieu 2006) through embedding or integrating entrepreneurial practices with other disciplines. In other words, entrepreneurial education should be taught to students as a method as opposed to knowledge.

Having said that educators and policymakers have been concerned for quite a long time about supporting the student' acquisition of the necessary aptitudes and knowledge required to function effectively in a world that is progressively oriented to and affected by technology, science and innovation (Epstein & Miller 2011). Acting in an entrepreneurial way and exercising entrepreneurial competencies are essential in the current society because of its uncertainty and constant change (Deuchar, 2006, 2007; Gibb, 2002). As a result, it was contended that enhancing students' abilities to think about innovative ideas and being able to carry them out in creative ways should become a priority in the educational sector whether those ideas are capitalized as creating a new venture and working on its consistent success or innovative attempts within established organization (Foss & Klein, 2012). However, incorporating entrepreneurial climate into scientific disciplines that has a reality-based focus to meet the rigors in academia is challenging to apply in a learning experience environment (Solomon 2007). That is why communication with actual practitioners of the teaching and learning approach can positively impact the reform efforts in education and eliminate its challenges (O'Sullivan 2015).

Entrepreneurship education does not have a stereotypical form for its measurement. Therefore, being a business owner is not compulsory to achieve an entrepreneurial mindset, however it makes a regular appearance resulting in individual's entrepreneurial behaviour (Stokes & Wilson 2010). That is why, the learning focus, objectives and expected outcomes of entrepreneurship education are varied for each age group applying its practices. In this essence, Lackeus (2015) designed the following graph to illustrate the focus of entrepreneurship in each learning stage in education (p.8).

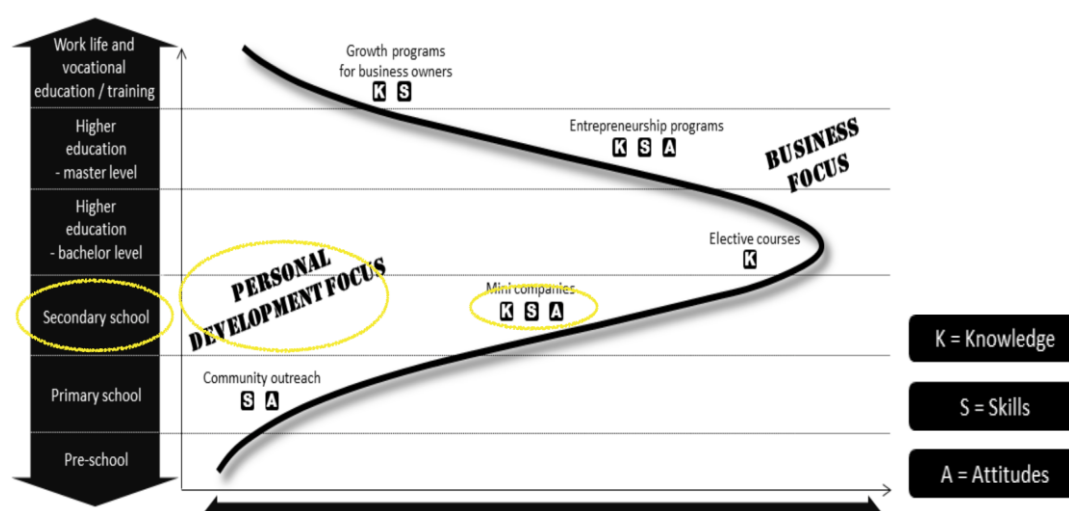


Figure 7: The Focus of Entrepreneurship in Different Educational Stages

Figure 7 illustrates that the main focus of entrepreneurial learning in the stage of secondary school (circled in yellow), is given to the development of students' personal and entrepreneurial knowledge, skills and attitude through the implementation of educational practices that provide students with the opportunity to be able to add values or establish mini companies. Thus, the acquisition of entrepreneurial knowledge should start in the high school stage through experiential learning activities to be prepared for the entrepreneurship education as an elective course in higher education (Lackeus 2015).

2.3.6 The relationship between entrepreneurship and STEM education

Although the entrepreneurial practices in STEM education may not be as well integrated or incorporated as they could be, the existence of many of the key entrepreneurial competencies arise in STEM research (Branes et al. 2014; Bevan et al. 2015; Hill 2016). Nonetheless, Atkinson & Mayo (2010) explained that entrepreneurial practices in the U.S have been recognized as an important mechanism within STEM classes to help accelerate students' entrepreneurial behaviour. Generally, research of entrepreneurial learning has shown that students who study entrepreneurship-related disciplines have more opportunities to develop an entrepreneurial intent than other students who do not have the chance to practice entrepreneurial learning in education (Hallam et al. 2015). The reason behind this fact is that students tend to gain positive entrepreneurial attitude if they have had a past entrepreneurial experience in adding value or starting business that provide them with the basic knowledge regarding the process of entrepreneurship and its prioritization as well. Thus, these educational experiences about entrepreneurial learning can place pupils ahead of market competitors lacking this valuable practice. In addition to providing students with the essential knowledge and skills, educational experiences about entrepreneurship help reduce students' anxiety regarding the ambiguous issues associated with launching new business (Stuart & Abetti 1990). In other words, entrepreneurial behaviour that is developed via past educational practices emerged as a valuable predictor of students' future entrepreneurial behaviour and plans. According to that, an empirical study found that the entrepreneurial intent is more among learners who studied business and were exposed to entrepreneurial events than students who solely studied STEM (Hallam et al. 2015). Therefore, it was suggested to integrate entrepreneurial practices into STEM education to launch STEM students in the direction of the entrepreneurial path (Ezeudu et al. 2013; Winkler, Troudt, Schweikert & Schulman 2015). Without this integration, the likelihood that STEM students will develop entrepreneurial thinking or pursue a clear entrepreneurial direction is low. Accordingly,

researchers in education have argued that students should be provided with the new learning opportunities that help engage them in a wide range of integrated learning tasks and activities outside school in order to develop the core competencies needed for the workplace (Asghar, Ellington, Rice, Johnson, & Prime 2012).

The literature explained that there are many educational practices that have been proven to be successful in infusing entrepreneurial activities into STEM education. Prior results of these empirical studies have mentioned in order to build upon. Organisjana et al. (2014) conducted a qualitative study through implementing the “holistic interdisciplinary teaching and learning entrepreneurship promoting methodology (HIEPTLM)” (p. 447) that asserted the appropriateness of this pedagogical strategy on facilitating entrepreneurial culture among school students. Moreover, the complexity level of the application of a maple-seed robotic flier (MRF) in STEM classes enhances students’ development of their designs and encourages entrepreneurship (Aslam et al. 2014). Furthermore, learning through STEM-rich tinkering has positive effects on enhancing the STEM workforce and advancing entrepreneurship (Bevan et al. 2014). A previous study identified three important phases for enhancing entrepreneurial initiatives that are exploration, evaluation, and exploitation in which certain skills are associated with each phase (Moberg et al. 2014). The exploration phase requires creative ability in order to identify proper opportunities, while planning ability and financial awareness are needed for the evaluation phase. Finally, the exploitation phase requires resource marshalling, teamwork and managing ambiguity or uncertainty (Moberg et al. 2014). More interestingly, it was argued that entrepreneurial STEM instructors prevail with regards to making imaginative and transformative learning situations, both inside and outside their own particular classrooms, to such an extent that the quality and amount of STEM learning results are uniquely superior in comparison to the outcomes of the traditional educational setting (Abd-El-Khalick, Gaffney, Price, Koehler & Martin 2011).

In line with those findings, Hamad et al. (2016) advocated the urgent need for promoting entrepreneurial learning proposed that schools and colleges should be partially funded by the government to encourage students to take risks through planning entrepreneurship initiatives. Forawi (2014) mentioned the importance of role models in enhancing students' career aspiration. Accordingly, it was recommended attaching successful stories of UAE entrepreneurs to the curriculum to influence students' cognitive behaviour (Hamad et al. 2016). Furthermore, it was statistically demonstrated that both male and female Emirati students have equal desire towards scientific and mathematics-oriented careers. However, educators should assist students who have lack of motivation and job aspiration through creating new educational tools and models that are able to explicate the links between the educational coursework and future career goals (Forawi 2014).

2.3.7 E-STEM Best Pedagogies

In general terms, teaching is perceived and interpreted as the effective act of supporting a student to learn (Kolb & Kolb 2005). According to Johnson, Yang, Nilsson, Jun, Larsson & Warell (2014), the discussion about teaching paradigms has been shifted from how knowledge is presented and transferred from a teacher to learners to how knowledge taught is perceived by the learners. In order to achieve this endeavour, the focus of the pedagogical relation in teaching has to be changed from a teacher-student-relation in which the content knowledge is the only transported product or the medium of this relationship to a student-subject-relation in which the teacher or the instructor is the facilitator of this relationship. The literature gives a special importance to the pedagogical relation between the main elements of the teaching and learning process, which are the teacher and the students as well as the content knowledge or the subject taught. In this regard, the teacher-student-relation is

usually emphasized in the deductive teaching methods that focus on the raw knowledge, facts and principles. Whereas, student-subject-relation takes place more successfully in the inductive teaching methods that give emphasis to values, experiences and skills that solve real problems (Sidhu, Johnsson, Singer & Souranta 2015). Thus, the “didactic triangle” (Johnsson et al. 2014, cited in Aaltio & Eskelinen 2016, p 338) was introduced to illustrate how the teaching paradigm was shifted in the following figure.

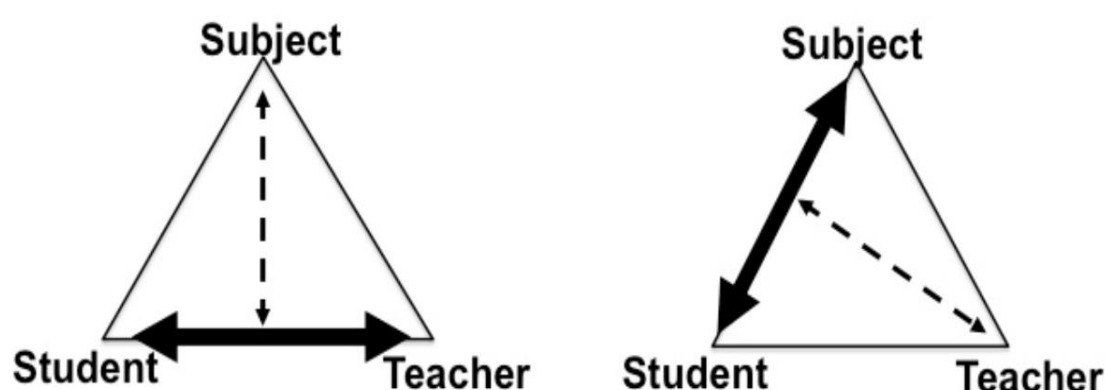


Figure 8: Didactic Triangle to show the Transferred Focus of the Teaching Paradigm

Figure 8 demonstrates how the emphasis of teaching paradigm was shifted from students-teacher (the left triangle) to student-subject (the right triangle) to generate more independent learners who can address the workplace challenges. The STEM literature introduces a wide range of pedagogical approaches including strategies, models and frameworks that are used to apply STEM in the classroom. Three main approaches (silo, embedded and integrated) are currently being applied to teach STEM in schools. The degree of STEM content used is the measurement of the distinction between these methods.

First: silo STEM approach refers to isolated instruction that gives more focus to knowledge acquisition and depth of understanding of each subject through a teacher-driven classroom (Dugger

2010). Second: embedded STEM instruction emphasizes the acquisition of knowledge through problem solving of different real-life contexts (Chen 2001). However, it might lead to fragmented learning because if students do not have prior knowledge regarding the embedded course content, the teacher has to cover this lack of knowledge separately (Hmelo & Narayanan 1995). Third: the integrated approach where all course contents are taught as one subject (Breiner et al. 2012). Moreover, specific standards from each subject matter that have been incorporated with the STEM implementation to solve a real-life problem should be assessed and evaluated in an experiential learning environment (Sanders 2009).

Proponents of STEM reform suggested that integrated approach is the most effective instruction because it helps students to develop valuable learning competencies through problem/project-based learning practices in a multidisciplinary or interdisciplinary integration (Wang et al. 2011). Thus, interdisciplinary integration is defined as a common approach of integrative instruction that, “focuses students’ attention on a problem and incorporates content and skills from a variety of fields” (Roberts & Cantu 2012, p. 113), while multidisciplinary integration requires connecting or linking content knowledge from different disciplines at different time in different learning settings (Wang et al. 2011). It should also be taken into consideration that teacher quality is an important determinant that impacts students’ learning because their qualifications including knowledge, beliefs and practices that they bring to the educational field are positively related to students’ outcomes (Hedges, Laine & Greenwald 1994).

In this essence, it was argued that teachers’ pedagogical training is required to help them master the integrative approach-based instruction as they often face difficulties to implement its practices (Williams 2011). Consequently, negative effects that eliminate students’ understanding such as the potpourri effect or polarity effect may occur as a result of teachers’ lack of structure in the classroom (Jacob 1989). The potpourri effect of ill-structured instruction takes place when teachers incorporate or integrate different knowledge from different disciplines, while they are not able to identify a common learning intention or to create one objective. Furthermore, the polarity effect appears when

teachers become marginalised over explicit course content restricting the consolidation of other disciplines' content (Jacob 1989). In order to avoid such negative effects, teachers should be trained to be able to select the appropriate teaching instruction and implement its features successfully (Roberts & Cantu 2012).

The historical perspective of integration clarifies that integrated curriculum was primarily connected to project-based learning in the 1920s, and then it was perceived in conjunction with problem-based learning in the 1940s and finally linked with experience-based practices (Beane 1997; Klein 2002), which refers to experiential learning. However., educational researchers believed that “There is no unique or single pedagogy for integrative interdisciplinary learning” (Klein 2005). Since the thinking paradigm was shifted from single teaching method to integrative learning practices (Taylor 1969) either through content integration or process integration in order to support the educational reform (Taylor 1969). Accordingly, the literature demonstrated the distinctive features of the experiential learning that differentiate its instruction from traditional formal methods.

Table 3: The Main Differences between Experimental and Traditional Learning Instructions

Differentiated Elements	Experiential learning instruction	Traditional learning instruction
Technique	Unusual and creative	Formal and conventional
Nature	Learning by doing and discovering	Learning by listening and following
Learning responsibility	Students are more responsible about the learning process	Instructors are fully responsible about the learning process
Learning context	In the classroom as well as in different real-life contexts	Only in the classroom
Resources	Unlimited sources of knowledge	Only academic textbooks
Expected Outcomes	Different for each student	Exactly the same for all students
Reflection	Is highly required	Rarely needed

Table 3 identifies the main aspects of differentiation according to Moon (2004). Hence, effective implementation of STEM activities takes place through different learning pedagogies that include either problem-based learning (PBL) (Sari, Alici & Sen 2018) or project-based learning (PjBL) in the school setting (Tseng, Chang, Lou & Chen, 2011; Wilhelm 2014). While integrating entrepreneurial practices required involvement in the field of the market to create new value or to start new business in order to achieve the anticipated objectives of this incorporation (Lackéus 2015) through real-life experiences. In this regard, incorporating entrepreneurial practices into STEM education can be instructed more successfully with integrative approach-based experiential practices.

PBL used in education today as an example of experiential learning strategies was originally developed from innovative health sciences curricula to improve the medical education in North American (Bound & Feletti 1997). Thus, the need for applying hypothetical-deductive reasoning process to learn the required content knowledge through PBL was recognized as a method of teaching medical students to cope with the rapid changes in scientific knowledge, theories and practices (Barrows 1994; 2000). In this regard, Anderson (1980) explained that the process of solving problems is a significant cognitive activity because it requires conducting a sequence of cognitive operations to achieve a certain goal. Accordingly, PBL in education is considered as a pedagogical approach that emphasizes solving authentic and ill-structured problems in a student-centred environment (Etherington, 2011).

There is no certain sequence to represent the implementation of PBL strategy. However, the characteristic structure of PBL was outlined by educational researchers (Stepien, Gallagher & Workman, 1993; Hmelo-Silver, 2004; Hung, 2009) and implemented recently in an empirical research study in the field of STEM education (Sari et al. 2018). The study explained the following stages to implement effective STEM project-based problem solving

- Problem Identification: educational scenarios or dilemmas are given to students to represent an engineering problem. Questions were raised in the class discussion to help students gain clear insights about the problem under investigation. Accordingly, students associate their prior knowledge with the new knowledge provided through a brainstorming process to determine all aspects being discussed.
- Data collection: students identify the necessary data and resources needed to solve the problem. Moreover, they decide on the required communications that might facilitate their endeavour.
- Research process: the learning journey is initiated to recognize the possible solutions that might address the given problem. Thus, students apply discovery-based learning that start by forming hypotheses, planning and making and repeating experiments to confirm or reject their hypothesis.
- Transferring and designing after collecting and analysing the data, students consider the obtained results and decide on the required engineering design that helps solve the problem. Thus, ideas discussed, available materials and equipment determined in order to create the new design (Sari, Alici & Sen 2018).
- Communication: students present their work to the class and reflect on their learning journey with all the challenges and obstacles they faced and how they were overcome. Besides, they explain the function and uses of their design.

Prominent researchers investigated the nature of the problem required in the interdisciplinary STEM education, and their results recommended using complex scenarios to enhance students' acquisition of advanced skills (Capraro, Capraro, & Morgan, 2013; Harmer & Cates 2007; Russell, Hancock, & McCullough, 2007) such as analytical and critical thinking, metacognition, creativity, collaboration, innovation and self-directed learning (Asghar et al. 2013; Casteldine & Chalmers 2012). PBL strategy is highly supported by the constructivist

theory because it allows collaborative students to work independently and build on their own knowledge (Vygotsky, 1978). Accordingly, the educational philosophers advocated the strong relationship between PBL implementation and successful STEM learning and explained that PBL is one of the most effective pedagogical strategies in teaching and learning STEM concepts (Capraro et al. 2013). According to Roberts & Cantu (2012), this strategy is called a, “design-based problem-solving process” (p. 111).

Similarly, student-centred learning is a main feature for PjBL but with more explicit guidance by the teacher. However, product creation is needed to solve authentic problems (Savery, 2006). The literature asserted that combining PjBL with STEM education can foster the effectiveness of the learning process and influence students’ positive attitudes because of the meaningful learning opportunities that are offered to them through the implementation of this approach (Tseng et al. 2011). Moreover, PjBL is considered as one of the important approaches in STEM learning because it helps scholars to implement better academic rigor (Edmunds, Arshavsky, Glennie, Charles & Rice 2017). Through applying project-based instruction, students are guided to employ integrated STEM knowledge in unique ways to represent a model (Boaler 2002) that achieves the learning objectives. Therefore, this instruction empowers learners to promote scientific and mathematical thinking by refining their pre-existing understanding, applying innovative technologies and discovering new concepts and principles in a project-based environment (Edelson, Gordin & Pea 1999; Wilhelm, Jackson, Sullivan & Wilhelm 2013).

IBL is built on posing and investigating a certain scientific question; however, it may not really be guided by any problems or result in designing a product (National Research Council, 1996). However, scientific inquiry can be linked to STEM education by formulating or posing questions to be answered through applying the features of effective inquiry process to inform learners before they become engaged in the STEM design that solves a certain

problem (Kennedy & Odell 2014). A recent study conducted in Dubai revealed that although, participating science teachers in the UAE showed progress in the implementation of inquiry features in their classes, which enhance students' engagement in the learning process, they still need more professional development programs that update and enrich their inquiry instruction (Eltanahy & Forawi 2019).

Johnson (1993) explained that student' intentions are not influenced by applying abstract principles in the classroom setting. Rather, more engagement in real-life problems is highly effective in developing reasoning skills that are needed to generate future decision makers. More recently, a study conducted to identify the skills needed to become an entrepreneur. This study proposed an educational model to develop entrepreneurial skills that suggests rethinking about the pedagogical approaches implemented in education regarding entrepreneurship to focus more consistently on real-life situations through PjBL and PBL practices (Sousa 2018). Furthermore, the literature explained that entrepreneurship education is not excluded to business start-up. However, it refers to all successful walks of life that lead to inspiring learners to be more creative, innovative and opportunity oriented. In this regard, the ability of students to create a value for others is considered as the common core of entrepreneurship, while business start-up is viewed as one of the several diverse ways for creating value. Accordingly, Lackéus (2015) suggested focusing on the value creation when infusing entrepreneurial practices into education to be able to identify students who show positive aptitude and develop interest in order to motivate and launch them in the direction of starting-up new business. More interestingly, the results of Birdthistle, Costin & Hynes (2016) recommended engendering entrepreneurial competencies in secondary students through experiential learning activities that emphasize entrepreneurial practices.

The current study adopted the definition of, “entrepreneurship is when you act upon opportunities and ideas and transform them into value for others. The value that is created

can be financial, cultural, or social” (Moberg et al. 2012, p.14). This definition is grounded in the emphasis of value creation as a key concept of entrepreneurial learning as well as a main goal for learners (Bruyat & Julien 2001). In this essence, Lackéus et al. (2013) was inspired by the notion of ‘Learning by doing,’ John Dewey labelled the entrepreneurial learning approach a “Learning-by-creating-value” (cited in Lackéus 2015, p. 11) to emphasize the main objective of incorporating the entrepreneurial learning in order to help teachers realize and apply the best pedagogical intervention that help students learn to add value for the community. The notion of entrepreneurial value creation could result in development of entrepreneurial competencies because it enhances students to learning knowledge, acquiring skills, motivating attitudes that all can be used to facilitate business start-up (Bruyat & Julien 2001).

2.4 Conclusion

Several competencies discussed within this chapter are associated with entrepreneurial behaviours, share resemblance with competencies acquired in STEM classes. As well as competencies, which are emphasized as essential to create a value for others and/or to start a new business. The literature suggests that incorporating entrepreneurial practices into STEM education can better develop the key entrepreneurial competencies of STEM students through turning their innovative ideas into economic impacts. Nevertheless, this might not always be the case because it is not a prerequisite for high school students to run their own business. Thus, value creation is the main emphasis during education in high school.

A strong theoretical underpinning supports the study claim in the light of eight important theories such as social constructivist theory, constructionist learning theory, situated cognition theory, interdisciplinary theory, and trilogy of success theory, entrepreneurial intention model, theoretical model of scientific competencies and the experiential learning

theory. Thus, social constructivist philosophy confirms that knowledge can be constructed through applying student-centred practices in a social learning environment (Vygotsky 1987). Constructionist learning theory emphasizes constructing knowledge through the artefacts' design process in a collaborative learning environment (Papert 1991). Situated cognition theory explains that constructed knowledge is situated and embedded in the learning activities where students' skills are developed in real life situation that consider the social and physical elements of the learning context (Lave 1988). Interdisciplinary theory refers to the usefulness of integrating knowledge from different fields of learning to provide students with more meaningful learning experiences rather than teaching disciplines separately (Jacobs 1991). The trilogy theory of success describes the three key factors (engagement, capacity and continuity) that should be emphasized in the learning process to ensure the success of students in the quantitative disciplines such as STEM (Campbell et al. 2004). According to the entrepreneurial intention model, the most important theoretical concepts responsible for enhancing students' entrepreneurial behaviour are; intention, knowledge and attitude to act entrepreneurially (Azjen 1991). Moreover, the theoretical model of scientific competencies that has a relatively high level of generality explains how competencies could be developed through emphasizing the relationship between the four main building blocks that characterized this model (Dietrich et al. 2015). Finally, experiential learning theory explains that meaningful learning opportunities are essential to engage students in authentic experiences and encourage them to reflect on their practices and outcomes to develop the required competencies (Kolb 1994). All theories are meant to be tested and their assumptions are challenged during the study.

Hence, it was noticed that intentionality could drive learning for better outcomes. There is no doubt that learning and practicing entrepreneurial activities during STEM classes in the school stage is crucial to increase students' awareness of developing a purpose by turning

their attention to the need of their STEM designs instead of wasting their valuable time making useless products that are not needed in the real market. According to this, the objectives from designing STEM products will be shifted from broadly educative goals to more concrete purposes which will help students to commit themselves to life-long practice launch them in the direction of self-improvement.

At the same time, implementing integrated practices of both entrepreneurship and STEM education help accelerate students' understanding of entrepreneurship and promote their ability to achieve an entrepreneurial mindset. Thus, the study developed an E-STEM model that is inherently interdisciplinary because during its implementation, students need to know the nature of materials used (science), they need to search and present their work progress (technology), they design their own products (engineering), they use measurements and proportions (mathematics) and they create values or deliver their products to the market (entrepreneurship). This incorporation can foster students' entrepreneurial behaviour in their life journey, which motivates them towards self-employment in the future in order to enhance the economic competitiveness of the country.

CHAPTER 3: METHODOLOGY

This section advances the compositional approach for designing the methodology of the current study. Thus, the selection of the research approach and methods applied are justified including a fair explanation of site selection, participants, instruments, ethics and techniques of data analysis that are emphasized in the study. Meanwhile, the main elements of the research design are discussed in detail; philosophical assumption, strategies of inquiry and specific research method in order to entail the most appropriate methodology that facilitate the objectives of the study. Although, STEM students are problem solvers, insightful and creative learners who work to invent new products, their work is usually lost unless their efforts are capitalized by determining the overarching goal that is using their work to create value to the community through entrepreneurial learning (Hershman 2016). Thus, the current research aims to incorporate entrepreneurial practices into STEM education through developing an educational model (E-STEM) and to examine the impact of this model on high school students' outcomes. Accordingly, the study has multiple objectives to achieve its purpose: (1) to explore educational leaders' views about incorporating entrepreneurial practices into STEM education, (2) to investigate the effective entrepreneurial practices within STEM classes that enhance incorporating entrepreneurial practices into STEM education as well as the challenges of successful incorporation, (3) to investigate participating teachers' demographics variables in relation to incorporating entrepreneurial practices into STEM education, (4) to develop a model of an entrepreneurial-STEM education (E-STEM), (5) to explore E-STEM teachers' beliefs regarding the impact of implementing E-STEM model on students' learning outcomes and (6) to examine the effect of E-STEM practices on students' entrepreneurial competencies.

This chapter consists of four main sections to provide an informative description of the methodology achieved. Following this introduction, the first section identifies the research approach utilized including its criteria, the rationale behind its implementation and the philosophical assumption that informs this approach. Moreover, a summary about the inception of the research approach is also discussed. The second section explains in detail the research method including site selection, participants and data collection with a clear description about each instrument. Furthermore, the pilot study that provides statistical evidence about the reliability and validity of both teachers' and students' questionnaires is also presented. The third section clarifies how both qualitative and quantitative data were analysed in terms of the method or database used to construct meaning of the obtained results. Finally, the fourth section discusses the ethical consideration utilised in the current study.

3.1 Research Approach

The nature of the study and its objectives are the key points that help decide on the most appropriate research approach to guide the path of the research (Fraenkel, Wallen & Hyun 2015). The current study conducted a mixed method approach and followed the criteria and procedures of Creswell (2014) to collect the data needed to fully answer the current research questions. Mixed methods research is defined as, “an approach to inquiry that combines or associates both qualitative and quantitative forms” (Creswell 2009, p. 4). Moreover, Johnson & Christensen (2014) defined this approach as a, “research that involves the mixing of quantitative and qualitative methods or other paradigm characteristics” (p. 488). Creswell (2014) explained that qualitative and quantitative approaches are not polar opposites, but they are considered as two ends of the research continuum. Thus, conducting one approach cannot efficiently address the current phenomenon under investigation (incorporating entrepreneurial practices into STEM education). Mixed research approach has a central

position in this continuum because it combines many features of both approaches which results in valuable contribution to the body of knowledge (Creswell 2009).

Accordingly, the reasons behind employing this approach through integrating both qualitative and quantitative inquiries is to overcome the weaknesses of each solitary approach and to strengthen the benefits through building on the results from the prior approach. This is to guide the second design in a single research study. In other words, mixed methods minimize the limitation of each single approach. Additionally, the bias inherent in one method can be neutralized, reduced or even cancelled by the integration of mixed approaches. More importantly, problems addressed in a field such as social science are often complex, which makes the excluded use of either qualitative or quantitative inadequate to address the complexity of its problems and is limited to satisfy its inquiries (Creswell 2009). More importantly, Fraenkel & Wallen (2012) explained that the usefulness of constructing a thoughtful combination of both qualitative and quantitative methods is to achieve better depth and breadth understanding of the study phenomenon. More depth insight is acquired by the combination of the two models of research designs because it expands the discussion and understanding of the research dilemma. Mixing methods across the research program is useful for acquiring a more complex understanding of a certain experience or phenomenon while simultaneously examining theoretical or developed models (Hason, Creswell, Pano Clark, Petske & Creswell 2005).

Thus, getting a methodological multitude is considered as a key criterion of applying a mixed methods approach because it facilitates the inquiry more effectively compared to each solitary method (Teddlie & Tashakkori 2009). A variety of equivalent terms was identified and used to express the criteria of this distinct research approach such as “integration, synthesis, quantitative and qualitative methods, multimethods, and mixed methodology” (Creswell 2009, p. 205). However, the term ‘mixed methods’ is used more recently (Bryman 2006) to integrate qualitative and quantitative designs. Moreover, the obtained results as well

as the future recommendations that are built upon the final conclusion become more significant and reliable (Creswell, 2013; Creswell & Plano, 2007; Driscoll, Appiah-Yeboah, Salib & Rupert 2007, Johnson, Onwuegbuzie & Turner 2007; Onwuegbuzie & Leech, 2004; Teddlie & Tashakkori, 2009).

Thus, the roles of both qualitative and quantitative components are intentionally decided according to the methodological rationale of conducting mixed research approach, which are development, complementarity and expansion (Greene, Caracelli, & Graham 1989). Thus, the purpose of the development refers to the need of results from each method to inform and develop the following phase, which means that the results from formal interviews with educational leaders will be used to develop the STEM teachers' questionnaire. However, complementarity aims to enhance, clarify and illustrate different parts of the phenomenon by different methods. Finally, the expansion seeks to extend the range of inquiry and its breadth. Accordingly, the most appropriate strategy for conducting this study is the design that allows combining two different mixed methods to achieve the goal of the inquiry.

According to the previous justification that highlighted the reasons, criteria and rationale of conducting mixed methods approach, the current study adopted the combination of qualitative and quantitative methods, as it is the most suitable approach to achieve the various objectives of this investigation. At first, the current inquiry sought to identify variables in relation to how entrepreneurial practices can be incorporated into STEM education in the UAE. The variables were then used to develop an educational model (E-STEM) that supports this incorporation. Secondly, the E-STEM model was tested through implementing its practices in STEM classes in a public high school to examine its impact on students' outcomes.

Creswell (2014) explained that there are three advanced mixed methods designs where multiple strategies of inquiry can be incorporated. In respect to the purpose of this study, a multi-project has to be conducted through two main stages: exploratory stage where variables are identified to develop the model, followed by the confirmatory stage where the developed model is tested in high school. Accordingly, the study adopted one design of these three advanced mixed methods, which is called “multiphase mixed methods” (Creswell 2014, p. 221). It was asserted that the purpose of the research study along with the proposed design of each stage must be considered and clearly identified to justify the preference of the selected method (Ivankova, Creswell & Stick 2006). Thus, the current study adopted a multiphase mixed method through integrating two different designs of mixed methods. One of them is an exploratory sequential design to represent the exploratory stage while the other is a convergent parallel design to represent the confirmatory stage. Accordingly, the following figure identifies the main stages of the multiphase mixed methods. Emphasizing the problem of the research and how the data is integrated (connected at the first strategy, and then merged at the second one) to address the study problem. It is the central reason behind adopting the multiphase strategy where sequential stages were used first to develop the proposed model, followed by concurrent phases to test the impact of this model on students’ outcomes.

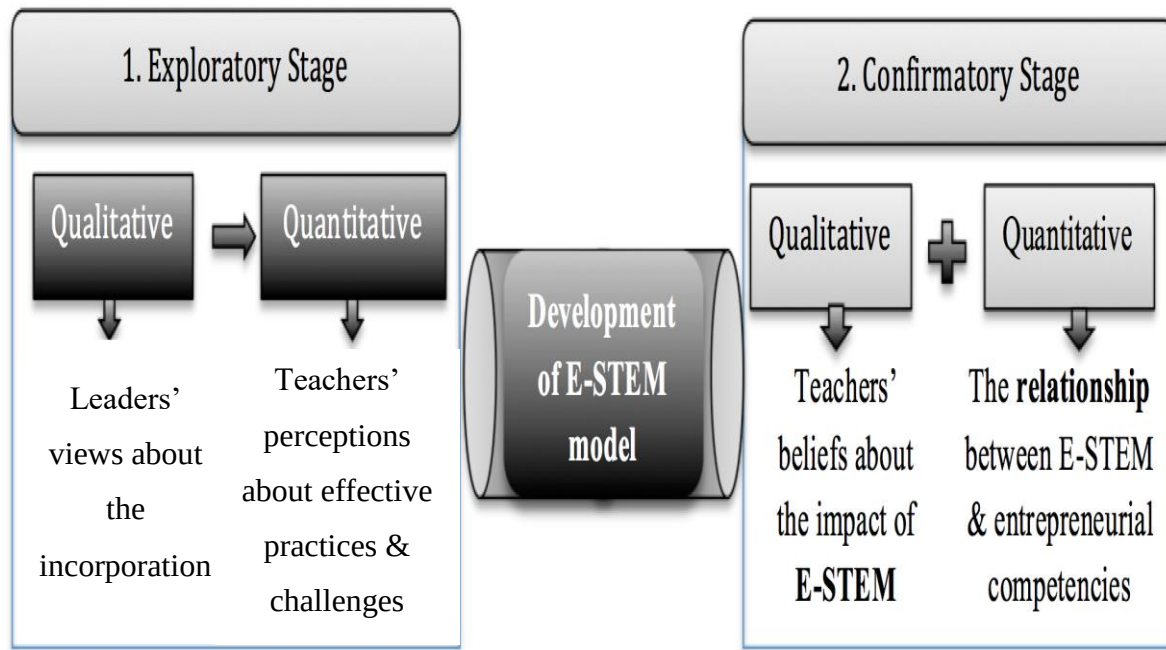


Figure 9: Stages of the Multiphase Mixed Methods

Figure 9 demonstrates the combination of methods utilized in the current study and refers to the unique nature of the current multiphase inquiry. Thus, the current research problem focuses on having a strong understanding about the needs for developing an intervention program (E-STEM) and investigating its impact in education as well as comparing different perspectives (academic leaders, teachers and students) drawn from analysing and interpreting both qualitative (closed-ended) and quantitative (open-ended) data. In this essence, the current multiphase research took the pragmatic position as a philosophical assumption where researchers should not be restricted by a single kind of approach (Creswell 2009).

The mixed model of inquiry adopts pragmatism because this philosophical assumption is driven by anticipated consequences as it arises out of situations and actions rather than antecedent conditions (Cherryholmes 1992). Instead of emphasizing the methods, pragmatists focus on the problem of the research and derive the required knowledge through

integrating all the available approaches to strongly understand all the aspects to address this problem (Rossman & Wilson 1985; Tashakkori & Teddlie 1998; Morgan 2007; Patton 1990).

Thus, Cherryholmes (1992) identified the roots of pragmatism and explained that it derived from the work of Peirce, James, Mead, and Dewey. The fundamental principle of mixed method research is to integrate both qualitative and quantitative paradigms in a strategic way to produce an overall research design that complements strengths and does not overlap weaknesses of each approach (Brewer & Hunter 1989). Johnson & Christensen (2014) identified the main concern of pragmatists is, “conducting research that provides useful answers to important research questions and provides “practical theory” that works locally” (p. 490). The pragmatism philosophy launches the research in the direction of finding reasonable evidences for conclusion that matches the epistemological standard. John Dewey called this desired evidence “warranted assertability” (Johnson & Christensen 2014, p. 490). Therefore, when the current research provided strong evidence regarding what practices are effective to enhance students’ entrepreneurial competencies during applying the desired incorporation, then this evidence met the standard. Hence, the educational research views the combination of multiple methods and perspectives as a strong approach. The current research relied on multiple sources of evidences to justify and warrant its findings. In addition, the pragmatic position of philosophical worldviews is also called “dialectical pragmatism” (Johnson & Christensen 2014, p. 32) in which multiple perspectives are effectively addressed. Dialectical nature refers to the back-and forth listening of different paradigms and synthesizing of multiple perspectives. Furthermore, this philosophy makes the theoretical lens including the value position of the research and its desired outcomes explicit. Guba (1990) defined the term “worldwide” as “a basic set of beliefs that guide action” (p. 17). Moreover, it reflects the general orientation of the nature of the research study and how the

world perceives its dilemma (Creswell 2009). Meanwhile, it mirrors the paradigm that is chosen to guide the research path. (Lincoln & Guba 2000).

According to that, there are major elements that characterize the pragmatic position: it is a problem-centred and pluralistic position, it is a real-world practice oriented that considers the consequences of actions (Creswell 2009). Simply, pragmatism is not committed to a specific-philosophical system, but it advocates drawing liberally from both approaches. Thus, pragmatic researchers are freely able to select the most appropriate and convenient methods, techniques and procedures that best meet both the purpose and the needs of the research, and to provide the best possible understanding of the problem under investigation (Johnson & Christensen 2014). In a nutshell, drawing on the mixed methods approach gives more meaningful research opportunities where multiple methods are applied, and the pragmatic worldwide opens the door for flexible philosophical assumption to collect and analyse different forms of data.

Although the methodological approaches of conducting an educational research used to be either quantitative or qualitative, applying one solitary approach cannot fulfil the purpose of the current inquiry. Regarding the quantitative research, it requires a controlled setting where objective types of measurements are used to collect numerical data in order to test the research hypothesis and answer the main questions of the study. However, the current study cannot rely only on quantitative data collection because incorporating entrepreneurial practices into STEM education is new in the UAE context and its variables should be explored. On the other hand, the qualitative research is usually employed in a natural setting where different forms of inquiries are required through collecting qualitative data in order to explore a social phenomenon in the light of the perspective of the recruited participants (Fraenkel & Wallen 2012). Similarly, the current study cannot rely only on a qualitative method because data should be expanded to facilitate the development of proposed model.

Therefore, the methodology of the educational research continues to evolve and develop where the approach of mixed methods appeared as a step forward to provide the researchers with wider opportunities to utilize the strengths of both the quantitative and qualitative designs.

A brief history of the evolution of the mixed design was traced because it is a relatively modern approach in the human sciences. The origin of this approach started with the work on triangulation to study the validity of psychological traits by Campbell & Fiske (1959). Moreover, the actual flourishing of mixed method research was in the late 1980s (Maxwell 2016). Thus, it was stated, “The formative period of mixed methods began in the 1950s and continued up until the 1980s. This period saw an initial interest in using more than one method in a study” (Creswell & Plano 2011, p.25). Accordingly, the emphasis in applying mixed approaches was growing steadily from the early 1990s (Teddlie & Tashakkori 2003) to make use of its benefits. On the other hand, it is worth knowing that conducting a mixed methods research is challenging in different aspects. For example: it is a must for researchers to be familiar with both approaches, extensive data collection is needed, it is a time-consuming approach because both numeric data and text must be analysed and interpreted effectively to answer the research questions with full saturation. Educational researchers had a consistent debate regarding whether qualitative and quantitative approaches are opposite paradigms or complementing the endeavour of each other. Quantitative research was characterized as a reductionist approach among its opponents, while adversaries of the qualitative approach criticised its elements and described it as a non-scientific approach. Gradually, a consensus has been reached to clarify that they are more complementary than adversarial (Ary, Jacobs, Sorensen & Walker 2013). However, there is no doubt that making use of both approaches influences the educational researchers to become more holistic and adaptable to any unexpected challenges during the investigation (Onwuegbuzie & Johnson 2006).

3.2 Research Methods

The multiphase mixed methods design is most common in multi-layered projects that require a combination of concurrent and sequential aspects (Tashakkori & Teddlie 1998). Many factors were considered in choosing this design. First, it is consciously selected to understand the impact of an intervention program (Creswell 2014) such as E-STEM model through collecting both qualitative and quantitative data over time to close the gap between students' STEM designs (students' work) and the market (community needs) where the expected outcome is to students' entrepreneurial outcomes. The following table shows the outline of the applied methodology.

Table 4: Outline of the Applied Methodology

Main Purpose	Develop and test E-STEM model that enhances the entrepreneurial competencies of STEM students			
Approach	Mixed Methods			
Advanced Design	Multiphase mixed methods			
Strategy	Exploratory sequential “exploratory”		Convergent parallel	
Intents	- Identify main variables - Develop an instrument - Develop E-STEM model		- Implement E-STEM model - Investigate the impact of E-STEM model on students’ entrepreneurial outcomes	
Paradigm	Qualitative	Quantitative	Qualitative	Quantitative
Objectives	Explore STEM academic leaders’ views about infusing entrepreneurial practices into STEM education	Explain the most effective practices that enhance incorporating entrepreneurial practices into STEM education as well as the barriers in the light of STEM teachers’ perceptions	Explore E-STEM teachers’ perceptions about the impact of E-STEM model on students’ outcomes	Examine the effect of E-STEM practices on students’ entrepreneurial competencies through a quasi-experiment
Population	60 STEM lead-teachers and 10 curriculum developers in all campuses (70 academic leaders in total)	250 STEM teachers in all of the UAE campuses	12 STEM teachers who were responsible of grades 10 & 11 in one campus	186 STEM students in grades 10 & 11 in the same campus
Participants	12-educational leaders	154-UAE STEM teachers	5-experienced teachers	113-STEM students in high school
Selection /site	Leaders selected purposefully	From 14 public schools in the 7 Emirates	- Career-oriented public school - STEM teachers and students in high school	
Sampling technique	Snowballing	Convenience	Purposive sampling	Six classes were assigned randomly to 2 groups
Instruments	Semi structured interview	Questionnaire	Focus group interview	Pre/Post test
Data Analysis	Coding & Recoding	Descriptive & Inferential	Summarizing & Interpreting	Inferential statistics

Table 4 demonstrates the unique structure of the method conducted including the standard methods and procedures addressed in the current study to achieve its purpose. The two popular scientific approaches (exploratory and confirmatory methods) were emphasized in this inquiry. Thus, the exploratory method is a bottom-up approach that follows the inductive perspective and seeks to make patterns about how entrepreneurial practices could be infused into STEM education. The flow of the process moves from data to patterns to theory, or from “particular to general” (Johnson & Cristensen 2014, p. 17). This scientific method is also known as a theory-generation approach that emphasizes the logic of discovery and starts by making observations about a certain phenomenon of interest, attempt to create thoughts and finally construct theories about how this phenomenon works. Accordingly, the emphasis was given to discovering and constructing data through applying exploratory sequential strategy. In contrast, the movement of the confirmatory method that considers the deductive perspective flows from theory to hypothesis to data, or from “general to particular” (Johnson & Cristensen 2014, p. 18) to emphasize the logic of justification. It is also called a traditional theory-testing hypothesis that seeks to justify the theory or hypothesis that was developed earlier. Thus, the emphasis of this scientific method was on testing and justifying hypotheses or theories through applying a convergent parallel strategy to collect the required data. Concisely, inductive approach generates the knowledge, while the deductive approach justifies the tentative knowledge.

3.2.1 Site, Sampling & Participants

The context of the current design is within the UAE Emirates where a group of fourteen public schools in different Emirates in the UAE adopted a unified STEM curriculum. It is already implemented in all of its campuses in Dubai, Sharjah, Ajman, Abu Dhabi, Ras-al Khaimah, Umm-al Qaiwain and Fujairah. The ultimate goal of these schools is to increase

the number of skilled-Emirati students and prepare them to be competitive in the labour market and to foster students' personal development through life-long learning (ACTVET 2017). Teachers in the departments of science, mathematics, technology and engineering are called STEM teachers. For each department there is a lead teacher who is responsible for the communications between departments to ensure effective STEM practices in each campus.

The target population of educational leaders included 60 STEM lead-teachers and 10 curriculum developers of STEM disciplines in all campuses. In addition to that, there were 250 STEM teachers who integrate and teach the four main STEM disciplines (science, technology, engineering and math) to high school students (grades 10 & 11). STEM teachers are often from different nationalities, whereas students are all Emiratis. Generally, different "mixed sampling designs" (Johnson & Christensen 2014, p. 272) were adopted in each method (table 4) where two criteria (time orientation and sample relationship) were considered.

For the exploratory sequential design, a multilevel sequential mixed sampling design was approved where qualitative and quantitative data were collected sequentially and from different samples (STEM academic leaders and STEM teachers). Researchers of the qualitative studies usually call the overall sampling strategy utilized a criterion-based selection (LeCompte & Preissle 1993) or purposeful sampling (Patton 1987, 1990) because the inclusion of participants is developed based on certain criteria that meet the purpose of the study. Johnson & Christensen (2014) explained that focus groups researchers usually rely on homogenous sample selection as an attempt to acquire a strong understanding about the phenomenon under discussion. Thus, a relatively small number of participants was adequate to obtain saturation and to fulfil the purpose of a qualitative-intensive research. Accordingly, the sample selection procedure adopted for the first qualitative phase (educational leaders' interview) in this design is snowball sampling as a non-random sampling technique (Johnson

& Christensen 2014). Where each volunteered participant was asked to identify one or more potential educational leaders who were responsible for STEM curriculum and implementation in the target schools from either STEM lead-teachers or curriculum developers. This technique of sampling was selected because educational STEM leaders could not be easily recruited for in-depth interviews. This process was extended for at least two consecutive months to conduct two focus group interviews.

In this regard, twelve STEM academic leaders were recruited conveniently from different branches of the same educational organization in the UAE. These participants included, 11 STEM lead-teachers (who were responsible for the implementation of STEM curriculum and its practices in different campuses) and 1 curriculum developer (who shared the responsibility of the development of STEM curriculum in one of the campuses) through a snowball sampling technique to explore educational leaders' beliefs about incorporating entrepreneurial practices into STEM education. In the first meeting, seven female leaders volunteered including lead teachers of math, science, engineering and technology as well as a curriculum developer. Based on the data given at this meeting, a male lead teacher from the business department was recruited purposively to attend the second meeting, which included another four female academic leaders from math and technology departments.

Afterwards, the questionnaire was distributed to the accessible population of 250 STEM teachers who work for the same group of schools in six different emirates (Dubai, Sharjah, Ajman, Abu Dhabi, Ras-Al Khaimah & Umm-al Qaiwain) in a convenience sampling technique. Johnson & Christensen (2014) defined the accessible population as, "The research participants who are available for participation in the research" (p. 292). Thus, an online questionnaire was sent to participants, however, only two ineligible responses were received, and they were excluded. Therefore, a paper-based questionnaire was sent to all campuses and the data collection for these papers extended to about five months. Although, the intended

sampling attempted to recruit all the 250 STEM teachers in all Emirates, and many consistent efforts were done to recruit as many STEM teachers as possible, the actual number of responses collected conveniently was 154 with the response rate 61.6% from the six Emirates. After, the data was collected, analysed and expanded, the variables were identified, and the E-STEM model was developed and prepared for the confirmatory stage in the second design. For the convergent parallel design, a multilevel concurrent mixed sampling design (table 4) was used where both qualitative and quantitative data were collected concurrently and from two different samples include STEM teachers, and secondary students in grades 10 and 11 in the campus of Ajman and who were nominated and willing to contribute to this study by implementing the E-STEM model. Hence, Brannen and Nilsen (2011), argued that the objectives of the research questions are the main factor that should be considered to decide whether a small or large number of recruited participants is needed for the interview setting. The implementation stage of E-STEM model was unique to Ajman where the population at this campus includes 12 STEM teachers and 186 STEM students from boys and girls attending grades 10 and 11. Teachers were recruited conveniently based on their long teaching experience of STEM with high school students as well as their interest in applying E-STEM model. Accordingly, a group of five experienced teachers who teach the main disciplines of STEM (science, technology, engineering and math), plus a business teacher purposively selected by the school admin because they are experienced teachers of STEM disciplines, so they were voluntarily recruited to implement the E-STEM model in their secondary classes. These five teachers were teaching the same high school classes that include 128 students where 39 of them in grade 10 and 89 students in grade 11 who were divided in six classes. All students were from the same culture (UAE) and have the same socio-economic background. The classes were assigned randomly to two main groups (control and experimental groups) in order to participate in the quasi-experimental design and received two different treatments. Unfortunately, 15 of the grade 10-girls withdrew from

the study because E-STEM is not graded. Accordingly, the total number of participating students in high school was 113. The following figure demonstrates the plan for quasi-experimental design conducted in the current study

Figure 10: Quasi-Experimental Design Plan

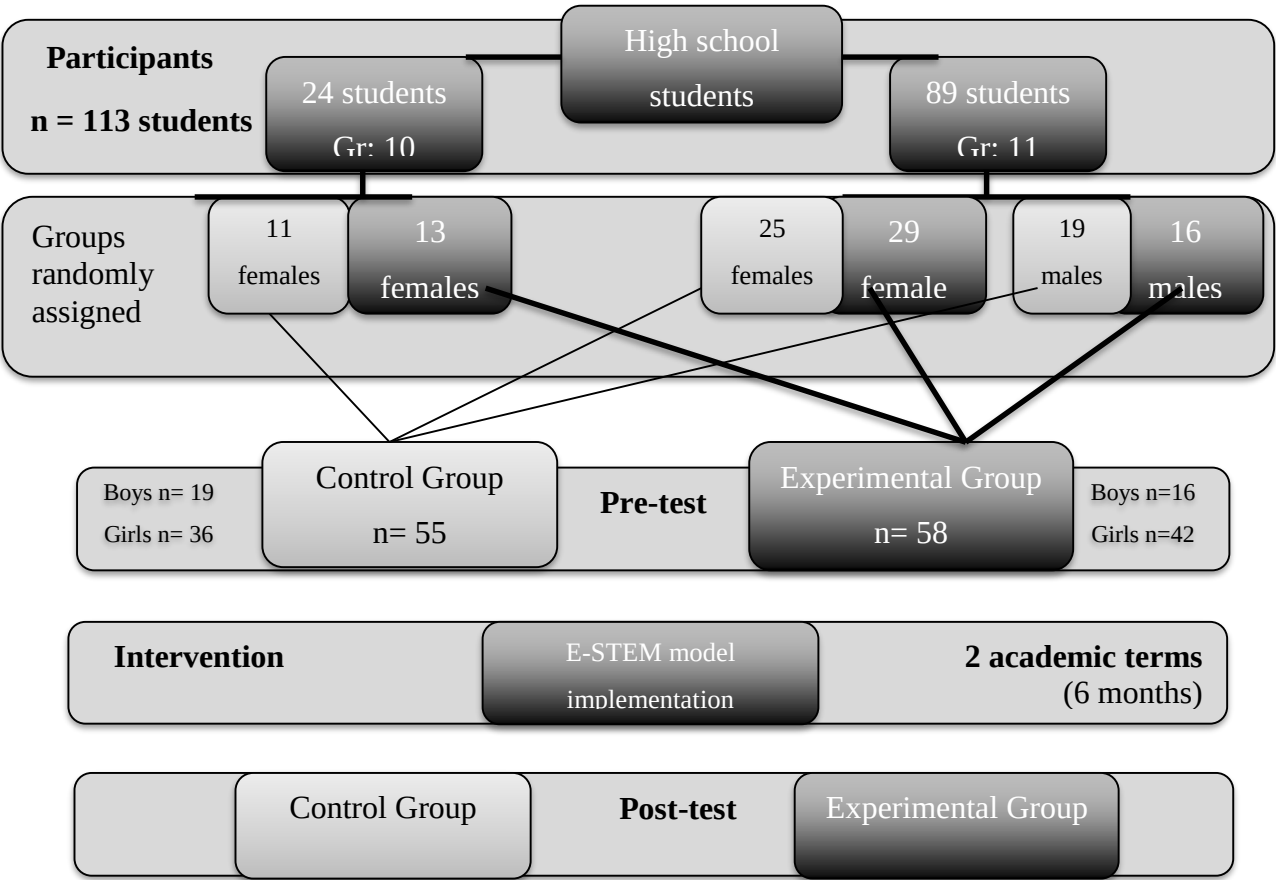


Figure 10 illustrates the number of recruited students and how the participating classes were randomly assigned to either the control or the experimental group. Thus, random assignment of participating groups resulted in 58 students (16 males and 42 females) located in 3 intact classes representing the experimental group. While, 55 students (19 males and 36 females) located in another 3 classes represented the control group. Accordingly, the students’ questionnaire (pre-test) was given to all the STEM students (113 students) before the implementation of E-STEM. Then after the implementation of the model that extended for 6

months (2 academic terms), the same questionnaire was distributed as a post-test to all of the 113 students (58 in the experimental group and 55 in the control group) to investigate the relationship between E-STEM model practices and students' entrepreneurial competencies. At the same time, a focus group interview was conducted with three of the nominated E-STEM teachers to express their opinions freely regarding the impact of applying E-STEM model on the students' entrepreneurial outcomes, while the other two teachers were not able to attend the interview and their responses were received by email.

In respect to the convergent parallel design, the inequality of the sample sizes of both participants engaged in the study (qualitative data collected from 5 teachers) and (quantitative data collected from 113 students) is acceptable in this design because the two databases gathered have different intents. For example: the intent of collecting the qualitative data from the five volunteered E-STEM teachers is to gain an in-depth understanding of the impact of applying E-STEM practices on students' outcomes. Whereas, the intent of collecting the quantitative data from the 113 students is to conduct statistical tests that measure the relationship between E-STEM model and students' entrepreneurial competencies.

3.2.2 Data Collection

The above table (4) demonstrates the outline of the methodology applied in terms of the approach, phases of the methodology, participants, site, instruments and type of data analysis proposed. Apparently, the multiphase mixed method was conducted through two main designs. Thus, this section represents the details regarding the data collection of each design, questioning development as well as the pilot study conducted for each instrument.

3.2.2.1 Exploratory Sequential Mixed Methods Design

Data was collected consecutively through the exploratory sequential design in two phases. The intent of this design is to identify variables that help develop the second instrument in order to interpret all the data and develop the E-STEM model that incorporates entrepreneurial practices into STEM education. The first phase of qualitative data collection and analysis was conducted to identify the required variables, followed by the second phase of quantitative data collection and analysis to develop the proposed E-STEM model. Thus, the research begins by exploring the educational leaders' views regarding incorporating entrepreneurial practices into STEM education and then the variables obtained in the findings of this phase was used to inform the second phase by developing a better measurement instrument (questionnaire) and administering it to the targeted sample (STEM teachers). In other words, the second database (quantitative) was constructed based on the conclusion of the initial database (qualitative) (Creswell 2014). Moreover, the preliminary data was collected by qualitative semi-structured interviews (Appendix 3) for two focus groups with 12 educational leaders from both STEM lead-teachers and curriculum developers who were purposefully selected in a snowball sampling technique to deeply explore their opinions regarding infusing entrepreneurial practices into STEM education (Fraenkel & Wallen 2012). The following figure illustrates the stages of the exploratory sequential mixed methods design.

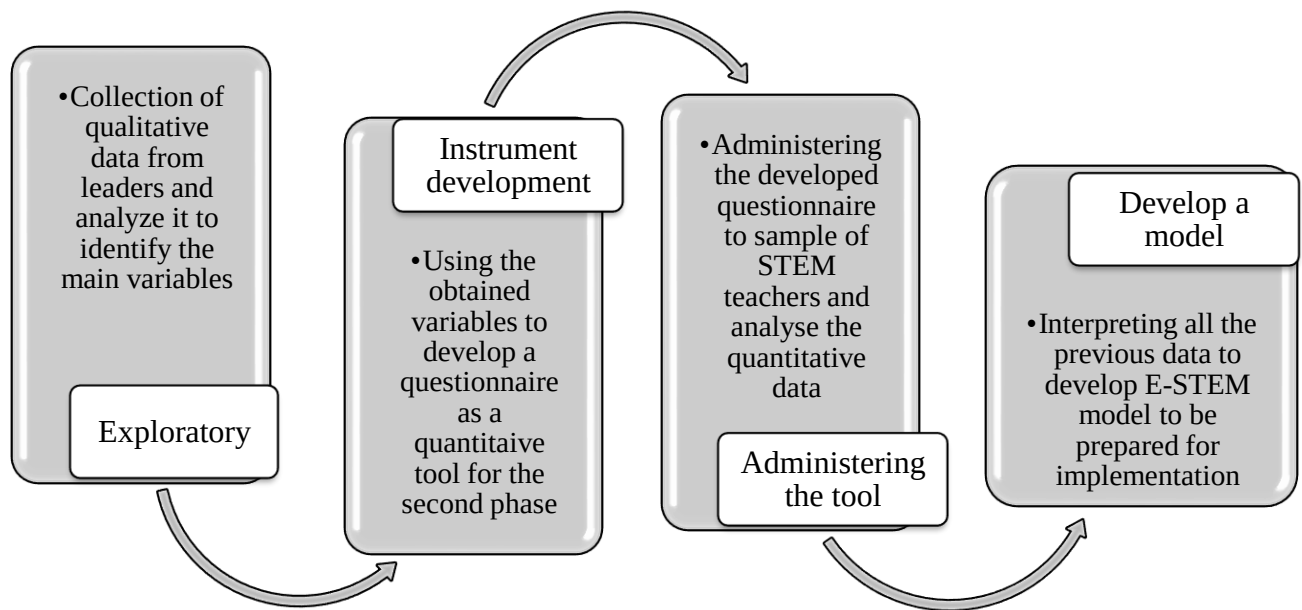


Figure 11: Stages of the Exploratory Sequential Mixed Methods Design

Figure 11 clarifies the sequential stages and how the mixed method integration of the qualitative and quantitative data was connected, which means that the analysis of the first data set was utilized to lead into the second one. Accordingly, the core intent of this exploratory strategy is to employ the data collected from a few participants like the twelve academic leaders in the qualitative phase to be expanded or generalized to a large sample of population like the 154 STEM teachers through developing a better research tool in the quantitative phase. Thus, a four-phase procedure was employed: exploratory data collection, instrument development, administering the developed tool and finally developing the E-STEM model.

The timing used for each stage varied based on the accessibility and availability of participants. Thus, the qualitative data collection and analysis took more than two months including the development of the quantitative instrument (STEM teachers' questionnaire), followed by five continuous months to administer the questionnaire to the recruited sample

of STEM teachers and to analyse its data. Finally, one more month was needed to develop the E-STEM model in the light of participants' perceptions regarding incorporating entrepreneurial practices into STEM education. In total, the exploratory sequential mixed methods design was conducted in eight consecutive months.

Several researchers have discussed the need to apply a qualitative investigation to study new experiences in a population without assuming there is, "One universal truth to be discovered" (Auerbach & Silverstein 2003, p. 26). Therefore, the exploratory stage of collecting the initial data was conducted in the light of the "constructivist grounded theory" (Mills, Bonner & Francis 2006, p. 26) as one of the popular approaches used to collect qualitative data in different disciplines such as education. Grounded theory is defined as, "a general methodology for developing theory that is grounded in data systematically gathered and analysed" (Strauss & Corbin 1994, p. 273). However, constructivist grounded theory positions the researcher as the author of a reconstruction of experience and meanings. Constructivism is a research paradigm that asserts that realities are social constructions of the mind where many constructs found in the literature, history, culture context and experiences can influence the researcher (Guba & Lincoln 1989). Furthermore, Creswell (2013) defined the theory as, "an explanation of something or an understanding that the researcher develops" (p. 85). The rationale behind selecting this qualitative approach is the need to construct a theory that is grounded in the initial data based on the concepts that are generated directly from academic leaders' beliefs. Thus, this theory is inductively (bottom-up approach) derived from the interview results that developed in-depth understanding of the variables related to infusing entrepreneurial practices into STEM education.

The key criterion of the strategy of developing a grounded theory is that it constructs an understandable theory that is closely related to real-world data (Johnson & Christensen 2014) because it is developed from primary sources of information like STEM leaders. Moreover,

its conceptual level and scope enhance generality to the point that it can be applied to a large set of people in the field, STEM educators are one example of this. Fortunately, it allows the researchers to identify controllable variables through this substantive theory to build on them for the next phase (Glaser & Strauss 1967). Meanwhile, the development of a constructivist grounded theory opens the door for further investigations, as it is a never-ending process. In this regard, Johnson & Christensen (2014) stated, “meeting the criteria of fit, understanding, generality, and control is a lot to expect from a grounded theory, especially if the theory is developed from a single research study” (p. 458). Based on this, the researcher in the current study who is considered, as the generator of the theory has to collect as much extensive information as is feasible until they reach the required saturation in order to be able to use the obtained data further (Glaser & Strauss 1967).

The most popular method in gathering qualitative data in a constructivist grounded theory strategy is the interview (open-ended). It serves to provide the participants with enough space to express their opinions freely in a natural setting in order to identify the required variables and construct a theory that is grounded from this data. Consequently, twelve academic leaders were recruited for the interview setting in two focus groups to respond to open-ended questions regarding the proposed incorporation and probe until no new concepts or variables were merged and the “theoretical saturation” (Johnson & Christensen 2014, p. 461) achieved. Furthermore, the results were thoroughly validated with the continual work of collecting and analysing the interview data. Hence, the development of the theory should be highly grounded in the initial data collected from STEM academic leaders, the actual practitioners (STEM teachers) who will attempt to implement this theory, should take the opportunity to become involved in making recommendations or suggestions to modify the constructed theory and produce the best applicable version for future implementation. That is why variables elicited from the academic leaders’ views in the prior phase were used to develop

a questionnaire for STEM teachers who work for the same educational organization around the UAE in different emirates. Finally, the main variables identified were first, effective STEM practices including; current practices (PBL/PjBL and value creation practices) and suggested practices to incorporate entrepreneurial practices into STEM education. Second is the ‘challenges’ that prevent or reduce the impact of this incorporation, while only teachers’ demographics were used as independent variables.

Thus, the second phase in the exploratory stage is the quantitative investigation that was carried out through a survey research (Fraenkel, Wallen & Hyun 2015) to expand the results and to have a broader understanding of the phenomenon under investigation. This phase aims to confirm and expand the qualitative results collected during the first fieldwork and to explore how the teachers’ demographics (independent) were related to other dependent variables (effective practices and obstacles) in order to purposefully identify the best participants to implement the E-STEM model (Johnson & Christensen 2014). Therefore, the emphasis of the scientific method in this quantitative stage is confirmatory or (top-down approach) in order to test the hypothesis elicited or the grounded theory developed in the qualitative phase. In this regard, the idea of mixing two paradigms transferred from seeking only convergence to integrating through connecting the two types of data when expanding on the findings of the prior qualitative data to inform the second quantitative phase. Ultimately, the meaning emerged from the exploratory sequential design was used to develop the proposed model E-STEM that had to be tested through the implementation stage in one of the educational campuses of the same organization.

Johnson & Christensen (2014) defined instrumentation as, “the whole process of preparing to collect data” (p. 112). Thus, any device or a tool whether a paper-based test or an online questionnaire is considered as an instrument. In the light of the main objectives of the current inquiry, two main instruments were used to collect the required data in the exploratory

sequential design; semi-structured interview with academic leaders to identify variables, followed by a developed questionnaire for STEM teachers to expand and interpret both the qualitative and quantitative data together in order to develop E-STEM model.

Instrumentation of the exploratory stage

The exploratory stage included two different instruments that were conducted sequentially. The first tool is the semi-structured interview with the academic leaders to collect qualitative data, followed by a teachers' questionnaire that contains close-ended questions to collect quantitative data as well as two open-ended questions to give more space to teachers to respond freely to the given questions. The following section provides more details about the structure of the two instruments.

Semi-Structured Interview

Two focus group interviews conducted face-to face to collect the first qualitative data in the research from educational leaders who are responsible for the implementation of the unified STEM curriculum in a group of public schools in the United Arab Emirates. The interviews aimed to explore their views about infusing entrepreneurial practices into STEM education. Thus, the interview protocol consisted of six primarily open-ended questions that were posed earlier to guide the interview path and to keep the participants in the group focused on the phenomenon being discussed (Kvale & Brinkmann 2009). Two scholars were responsible for recording the responses by making handwritten notes as well as typing on laptops because audio and videotaping were not permitted. The interview aims to highlight the academic leaders' understanding of entrepreneurial learning. Furthermore, it gives them the opportunity to elaborate the link between their views regarding the proposed incorporation and the daily STEM practices. Thus, their descriptions, explanations and predictions were used to build on them to develop the educational model (E-STEM) for effective implementation, in order to inform curriculum developers and policy makers in the light of

the future recommendation of the research. The two interviews were conducted in English. However, it was more convenient for some participants to involve some Arabic terms to their responses during conversation.

Each interview sitting averaged between 70 to 85 minutes in length. At first, the leaders were asked the six open-ended questions to allow for probing and to encourage them to provide the maximum amount of appropriate and useful information. These questions focused on STEM leaders' knowledge regarding entrepreneurial learning and their views about the effect of STEM education on entrepreneurial learning. Together with whether the STEM program used in their schools supports the development of students' entrepreneurial competencies, and the expected barriers that may eliminate the integration of entrepreneurship in STEM education. However, it was observed that the majority of participants were unable to differentiate the meaning of two questions: What is the contribution of STEM education to entrepreneurial learning? And what is the impact of STEM education on the development of entrepreneurship education in the UAE? Accordingly, they were combined, and the total number of questions presented in the analysis section was five.

Schensul, Schensul & LeCompte (1999) stated three key standards to maintain the interview's quality. The first principle is to maintain the stream and scrutiny of the questions and responses. The second is to maintain a positive connection with the interviewees. The third and last is to avoid bias or abstain from predisposition. In this regard, the interviewer was the researcher of this exploration where all participants were asked the same open-ended questions with comparable request. Additionally, the qualitative nature of the inquiry encouraged respondents not to hesitate to share their observations, encounters, and state of mind concerning the topic. Furthermore, it allowed them to contribute freely in shaping the conversation back and forth to connect their ideas and justify their attitudes and enrich each other's views and experiences with any examples and stories (Bogdan & Biklen, 1998) that

all supported the research endeavor. With specific consideration given to any potential for biasing the interviewees' comments or to abstain from affecting member's answers, the questioner was an uninvolved member during the two meetings. The questioner read the inquiries exactly as worded ensuring to reduce any accidental impact. Meanwhile, probing was considered when more clarification was needed. Two different scholars recorded precisely all the responses as given to be compared. Additionally, the researcher provided impartial clarifications when further illumination was required. Finally, an outline report was made to gather what the scholars recorded in order to interpret the information obtained more easily, and to avoid any unexpected contribution.

Hence, the most popular instrument of collecting qualitative data is the interview because it usually helps researchers to gather more authentic data about the perceptions of participants and their real experiences regarding certain topics than any other forms of data collection (Melles 2005). Johnson & Christensen (2014) defined the interview as, “A data collection method in which an interviewer asks an interviewee questions” (p. 228). Thus, the open-ended questions of the qualitative interview are often posed to investigate relationships, plans, behaviors and roles of certain phenomenon through focusing on beliefs, culture, experiences, and problems of the target population (Tuckman & Harper 2012). Educational researchers have perceived the power of this tool in its ability to enhance the acquisition of deep insight into the participants' personal experiences, incidents and practices, that are meant to be studied (Seidman 2013).

The strength of an in-person interview is that it allows the interviewer to obtain additional information about the research problem by using probing questions to attain better response clarity. Therefore, the current study adopted the semi-structured interview because it is the most convenient and effective type of interview that meets the purpose of the study (Kvale & Brinkmann 2009). This is because open-ended questions were designed earlier to

emphasize the focus of the study as well as allowing for probing with complete avoidance of both multidimensional and leading questions (Yıldırım & Şimşek, 2013, cited in Belet Boyacı & Güner, 2018). Moreover, a semi-structured interview is a flexible form of collecting data because it combines the advantages of both structured and unstructured forms where prepared questioning techniques and thematic approach are utilized to keep the research scope maintained in a natural manner. Besides, it provides the interviewee with enough space to ask additional questions based on the responses of the interviewers, who are free to express their feeling, attitudes, beliefs, understanding, context and predictions in their own language and terms (QU & Dumay, 2011) regarding integrating entrepreneurial practices with STEM curriculum.

In order to enhance the content validity of the interview protocol (Johnson & Christensen 2014), an educational professor reviewed its questions and his feedback was used to modify some terminology. In addition to that, a record of the interview dialog was written on the laptop during the interview by two different scholars to improve the descriptive validity of the data collected. In order to enhance trustworthiness of data through triangulation, the interview form was initially given to two academic leaders who work for different schools in Dubai to respond at a face-to face meeting (pilot scheme) in order to re-design the questions that could not be comprehended (Belet Boyacı & Güner 2018). The interview started with ten questions and was then edited to six questions, followed by some adjustments that were made to simplify and clarify the terms and words used as well as to exclude or combine any overlapping questions in order to avoid confusion. To clarify, the interview protocol began by asking 10 questions and was reduced to six as a result of the piloting, and then reduced again to five as a result of the first interview discussion.

In addition to that, Krippendorff (2004) explained, “Intercoder reliability requires that two or more equally capable coders operating in isolation from each other select the same code

for the same unit of text” (p. 217). Accordingly, the transcript was given to another researcher to work autonomously keeping in mind that the end goal is to capture salient themes of no less than three questions to be coded (Ajzen 1991) to enhance intercoding reliability. Furthermore, Campbell, Quincy, Osserman & Pedersen (2013) argued that if the researcher is more knowledgeable about the subject matter analyzed than any other coders, the “intercoder agreement” (p.297) should also be taken into consideration. Therefore, coding discrepancies were reconciled through a telephone dialog discussion that took place after until the agreement was achieved. Nevertheless, a significant level of agreement with respect to the emerged themes appeared and it was conceivable to overlap the selected codes and categories used for interpretation.

STEM Teachers Questionnaire

The questionnaire of STEM teachers consisted of four main sections with a suitable range of elements (De Vaus 2002) about 35 quantitative items in total, where the first section asked about 5 demographics, followed by two sections focused on 30 closed-ended items (standardized elements) in order to measure the variables. Findings of the research in education asserted that teachers as the actual practitioners of the curriculum play a vital role in many aspects such as educational reform in general and students’ outcomes. Thus, literature of STEM suggests the characteristics of teachers that affect their academic performance in the classroom like gender, teaching experiences and qualifications achieved (Kimani, Kara & Njagi 2013). Accordingly, the first section of the developed questionnaire seeks to identify the demographic information about the participating teachers including five variables that are emirate, gender, teaching experiences, academic qualifications and subject taught that all were identified as affecting the application of the current instructional practices

in STEM classes to enhance entrepreneurial outcomes and the challenges of incorporating entrepreneurial practices into STEM education.

One of the important reasons to employ a questionnaire in the field of human sciences is to capture snapshots of educational efforts and practices to study how it functions effectively (Hanson et al. 2005). The second section in the questionnaire asked STEM teachers about their effective teaching practices including current STEM practices (problem-based/project-based learning practices and value creation practices) that enhance students' entrepreneurial outcomes as well as the suggested practices that could be added to the STEM course pedagogy in order to support students' entrepreneurial learning. Thus, at this section, two clusters were designed to represent each dimension or variable that includes a set of items. For example: cluster A included items from 1 to 11 to investigate the extent to which teachers emphasize applying PBL/PjBL practices in their STEM classes to promote entrepreneurial learning. In addition to three items that focus on current practices regarding value creation. Consequently, five main options were provided to select the most suitable response; 5= always applied, 4= often applied, 3= occasionally applied, 2= rarely applied and 1= never applied. While, cluster B has items from 15-22 aims to explain teachers' perceptions regarding the suggested practices that should be added to the STEM course pedagogy in order to facilitate entrepreneurial learning with different options; 5= strongly agree, 4= agree, 3= neither agree or disagree, 2= disagree and 1= strongly disagree.

The third section included items from 23 to 30 that were added to identify the expected challenges of integrating entrepreneurial practices into STEM lessons in the light of teachers' perceptions with the same five options that are strongly agree, agree, neutral, disagree and strongly disagree. Finally, two open-ended questions were added to validate the data (McMillan & Schumacher 2010) and to provide teachers with an adequate space to freely express their opinions.

Hence, Likert-type rating scales are the most broadly utilized strategy when estimating psycho-educational measurements or constructs (Lee & Paek 2014). Considerable attention was paid to the scale development to design an appropriate questionnaire in order to measure teachers' perceptions as precisely as possible. It was found that the psychometric properties of the scale are optimized when the optimal number is between 4 and 7 response categories. Thus, the more response alternatives, the better validity and reliability obtained (Lozano, García-Cueto, & Muñiz, 2008). Accordingly, the current study adopted a 5-point rating scale or what is also called a fully anchored rating scale, which is defined as, "A rating scale on which all points are anchored" (Johnson & Christensen 2014, p. 202). Thus, the proposed anchors give reference points to guide the participants to better express their perceptions. The literature suggests that the pattern of findings is not affected by omitting or adding the middle alternative (neutral) (Converse & Presser 1986). However, using this middle alternative is useful to give the participants the free will to lean one way based on their experiences, and not to irritate any of them if he/she holds a truly neutral side regarding the issue under investigation. The following table shows fully the Anchored rating scale used in each cluster in the developed questionnaire of STEM teachers.

Table 5: Fully Anchored Rating Scale Used for each Cluster in the Developed Questionnaire of STEM Teachers

Variable	Section s	Items	Dimensions	Questionnaire Answer Options				
				5	4	3	2	1
Effective STEM Practices	Section 1 Current Practice s	Question 1 to 11	PjbPS Practices	Always applied	Often applied	Occasionally applied	Rarely applied	Never applied
		Question 12 to 14	Value Creation Practices	Always applied	Often applied	Occasionally applied	Rarely applied	Never applied
	Section 2	Question 15 to 22	Suggested practices	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
Obstacles	Section 3	Question 23 to 30	Challenges of incorporation	Strongly agree	Agree	Neutral	Disagree	Strongly disagree

Table 5 identifies the Likert scale used in the developed questionnaire of STEM teachers where (5= always applied, 4=often applied, 3= occasionally applied, 2= rarely applied and 1= never applied). The link to the online questionnaire was sent to all academic leaders to be distributed among their teachers in all campuses. Unfortunately, few responses were received in 4 weeks, even after many reminders were sent. In order to enhance the response rate, the questionnaire (Appendix 4) was distributed again manually among 250 STEM teachers who work in the fourteen campuses to be recruited as a homogenous sample (Creswell 2014). All science, technology, engineering and mathematics teachers were targeted conveniently to respond to the questions. The process of distributing the questionnaire and collecting responses from six Emirates extended for about four months.

Johnson & Christensen (2014) identifies the questionnaire as, “a self-report data-collection instrument filled out by research participants (p. 191) that is used to measure a variety of characteristics such as thoughts, perceptions, attitudes, feelings and beliefs regarding the subject matter. There are substantial benefits to utilizing a questionnaire as a means of

collecting quantitative information in instructive research. It ensures the anonymity of participants, which encourages them to respond more fairly and decently to the given questions. It saves time and cash because it is relatively easy to respond. The collected data can be effectively examined by the inquirer (Hanson et al. 2005; Rattray & Jones 2007). Despite this, the utilization of a questionnaire conveys some weaknesses. This relies upon how questionnaires are not versatile and cannot examine nor advance any annotations, considerations or thoughts that a respondent makes. Furthermore, formed responses to close-ended items may oblige individuals who may impart more easily orally (Hanson et al., 2005). Besides, it is a big challenge to take educators' perceptions of as wide a theme as STEM learning through limited choices. Moreover, members' experience contrasts from the researcher's, which makes it hard to grasp their correct views with respect to the target of the exploration. Likewise, every member may understand the inquiries uniquely in contrast to what is planned by the analyst. To avoid such limitation, open-ended questions were added to provide teachers with more opportunities to expand and express their perceptions. Additionally, a few focuses including; privacy of respondents, rights to pull back whenever desired, degree of threat and risk or sensibility of the created questions were considered (Cohen, Manion & Morrison, 2013).

Hence, it was intended to use this quantitative data to help develop an educational model (E-STEM). Developing or modifying an appropriate instrument is essential to accurately measure the intended variables in the light of the proposed demographics (Williams, Walter, Henderson & Beach 2015). Accordingly, this questionnaire was detailed and specific because it was developed to expand as well as to confirm the data collected from the qualitative phase. Moreover, the existing research literature was reviewed and considered to identify the main elements involved in any available related instruments that have already been utilized in order not to miss any valuable element in the study. The principle of standardization was

considered through using closed-ended items to ensure maximum comparability of data gathered. However, the questionnaire is characterized as a “mixed questionnaire” (Johnson & Christensen 2014, p. 199) because despite weighting more emphasis on closed-ended items, two open-ended questions were included at the end of the questionnaire to avoid the potential limitation of standardization. The purpose of collecting this quantitative data is to assist in interpretation of qualitative results (Creswell 2014). Further, the content and organization of the developed questionnaire corresponds to the objective of the quantitative phase of the current research. Meanwhile, natural and familiar English language was also considered to avoid the use of any jargon or technical terms that might confuse the participants. In a nutshell, many factors were considered to generate the main questions and to develop a cross-sectional questionnaire such as the main variables identified from the educational leaders’ interviews, the study scope and nature, existing literature and the theoretical assumptions.

Piloting of STEM Teacher Questionnaire

A pilot study is a basic component incorporated into the examination outline and is considered as a profitable method that helps with clarifying the exploration's statement, proposed questions, and measurement procedures (Glesne 2011). Despite the fact that, leading a pilot test may not ensure the accomplishment of the inquiry, it expands the odds of progress by giving significant experiences of the exploration techniques and the instruments planned. That is why it is useful as a feasibility and attainability research as it has been considered as a smaller form of a full-scale investigation (Teijlingen & Hundley 2005).

Thus, a pilot study was conducted as a simple scale methodological test (Fraenkel & Wallen 2012) where a homogenous convenience sample of 42 participants (18 science, 11 technology and 13 mathematics teachers) who teach STEM in different private schools in Dubai were employed conveniently to respond to the STEM teachers’ questionnaire. Hence,

the main population of target participants is 250 STEM teachers as mentioned before. So, 15% of the population was approved as a suitable size of the proposed sample for effective piloting (Kotrlík & Higgins, 2001).

Piloting the instrument was essential to make sure that it was not too complicated for the intended respondents and to enhance the appropriateness of the context being selected. Moreover, the two main psychometric properties (validity and reliability) of the questionnaire were considered and assessed because in spite of the importance of reliability, it is not sufficient for validity of the assessment procedures. Adding to that it helps determine the appropriate sample size through estimating the variability in findings (Williams, et al., 2015). According to the feedback given from the pilot test participants, minor adjustments were carried out to better suit the objectives of the study. For example: the matter of vocabulary was raised among STEM teachers. A concept like ‘venture enterprise’ was an unfamiliar word to be questioned because STEM teachers are not business-oriented individuals. Thus, it was suggested to simplify and replace this concept to ‘value creation or business start-up’. The main purpose of piloting is not only refining the word clarity and content relevance for the problem discussed but also to determine the approximate time needed to fully respond to all items in the questionnaire. Therefore, the pilot study was conducted under the supervision of an expert who reviewed the layout of this instrument and who approved the content, clarity and quality of the developed items of each cluster in the questionnaire (Simon, 2011).

Validity and reliability of any developed instruments are critical characteristics that should be assessed to test the trustworthiness of the measurement (Tavakol and Dennick 2011). A research tool cannot be valid unless its internal consistency is ensured. Thus, the validity of the developed questionnaire prepared for STEM teachers was measured on SPSS software platform through testing both construct validity using the approach of approximation

discrimination as well as the internal validity through determining the main factors that accommodate the proposed variables of the questionnaire. Meanwhile, reliability of the research instrument reflects the capacity of this measurement tool to gauge consistent results when utilizing it again and again under similar conditions (Tavakol & Dennick, 2011). Accordingly, the most popular method to assess reliability is the test of Cronbach's alpha coefficients that was conducted on SPSS to indicate its internal consistency (Rattray & Jones, 2007).

Validity of STEM Teachers Questionnaire

Johnson & Christensen (2014) explained that the validity of the instrument, "refers to the accuracy of the inferences or interpretations you make from the test scores" (p. 165). Thus, assessing the validity of the research instrument is an essential procedure to ensure usefulness, correctness and meaningfulness of inferences made by the inquirer (Fraenkel, Wallen & Hyun 2015). In this essence, an educational expert evaluated the appropriateness of the instruments format to enhance the content validity.

Internal Validity by Confirmatory Factor Analysis

Confirmatory factor analysis was conducted twice. Firstly, with 42 participants to piloting the questionnaire. Although many researchers recommended a large sample size for factor analysis test, researchers of statistics argued that factors of a small sample size could be identified if at least 10 participants responded for each variable in the questionnaire being employed (Yong & Pearce 2013; Kuncze, Cook & Miller 1975; Nunnally 1978 cited in Arrindell & Van der Endre 1985), and values of all communalities are above 0.6, or at least 0.7 communality mean is achieved (MacCallum, Widaman, Zhang & Hong 1999). Thus, the questionnaire of the pilot study received 42 eligible responses as a total number of cases, while 4 variables were proposed, which means that the ratio of subject-to-variables is 10:1. Moreover, the mean of communalities was rounded to achieve 0.7. Accordingly, factor

analysis was conducted, and the results (Appendix 9) showed that each one of the four proposed variables loaded more heavily in one factor.

Secondly, when the questionnaire was conducted with 154 participants to explain their perceptions in order to determine the number of variables that should be used in the inferential statistics. Factor analysis was conducted as a data reduction method to identify a pattern of results where each variable should load onto only one factor. MacCallum, Widaman, Zhang & Hong (1999) recommended at least 100-sample size to conduct the factor analysis test when variables are less than 20 (Gorsuch 1983). According to this recommendation, confirmatory factor analysis was employed because the current questionnaire obtained 154 responses and the proposed number of variables is only 4 (Kim & Mueller 1978b). Thus, Varimax rotation as a method of extraction was emphasized to show the number of factors that produces the interpretable results. Accordingly, the findings of the test showed that three variables (PBL practices, value creation practices and suggested practices) were loaded heavily in one factor (Appendix 10), which is then called effective practices that enhance entrepreneurial practices into STEM education. Moreover, the variable of obstacles was loaded separately in one factor. In this regard, two main factors were identified that are effective practices and obstacles in order to conduct the required inferential statistics.

Reliability of STEM Teachers Questionnaire

The reliability of the instrument was defined as, “the consistency of stability of the test scores” (Johnson & Christensen 2014, p. 165). Fraenkel et al. (2012) stated, “as reliability improves, validity may improve” (p. 155).

Table 6: Cronbach's Alpha Coefficient of the Main Variables of STEM Teachers' Piloting Questionnaire

Clusters	Dimensions	No. Of items	Alpha Coefficient	Mean of inter-item correlation
2. Effective Practices				
Current Practices				
	(PBL) Practices	11	0.838	.329
	Value Creation Practices	3	0.893	.738
	Suggested Practices	8	0.711	.246
3. Obstacles		8	0.704	.252
Total score		30	0.747	.133

Table 6 shows that the scores of Cronbach's Alpha of the main variables of the questionnaire ranged between (.711 and .893), which reflects very good internal consistency level of results being obtained. Additionally, the average correlation of elements of each dimension ranged between (.252 and .738). The positive relationship indicates that high scores of variables are accompanied with high scores of other variables and vice versa. In respect to the total scores of all of the 30 items of the newly developed instrument, the insignificant value of the average correlation of all items (.133) and the Cronbach's alpha score is .747 indicate that items are not correlated and all of them are reliable to be used for the basic study (Rattray & Jones 2007).

After conducting the questionnaire with the STEM teachers, 154 responses were received and the reliability test of the developed questionnaire was conducted again using Cronbach's Alpha coefficient for clusters number two and three, that contain 30 elements in total. This test was described as an essential method in the evaluation of the accuracy and consistency of the scores, or the stability of the given responses (Tavakol & Dennick 2011).

Table 7: Values of Cronbach Alpha Coefficient of the Variables in the Teachers' Questionnaire

Clusters	Dimensions	No. Of items	Alpha coefficient
2. Effective Practices			
- Current Practices			
	PBL Practices	11	0.705
	Value Creation Practices	3	0.831
- Suggested Practices		7	0.614
3. Obstacles		8	0.728
Total score		29	0.857

Table 7 shows the values of Cronbach's Alpha coefficient of each of the main variables of the study. The reliability test for the elements representing the perceptions of teachers regarding the current practices that enhance entrepreneurial learning, divided into PBL practices and value creation practices, reflected high values of Cronbach Alpha (.705 and .831) respectively. On the other hand, the reliability value of elements representing the suggested practices that can promote entrepreneurial learning in the UAE was very low (.335). Therefore, element 2 was deleted and the new value of reliability was (.614). Nevertheless, on conducting the reliability test on elements of the obstacles that decelerate incorporating entrepreneurial practices into STEM education, the value was (.728). Finally, the value of the Cronbach Alpha of the all items of the questionnaire (.857) excluding the deleted item reflected very high reliability and consistency of responses. Accordingly, the total number of items in the questionnaire that will be analysed below is 29 rather than 30.

3.2.2.2 Convergent Parallel Design

The convergent mixed methods strategy expands on the historic perspective of multi-trait opinions from Campbell & Fiske (1959) who believed that understanding psychological traits requires collecting different forms of quantitative data. However, the mixed methods design

extends this conceptualization to include gathering different views or different forms of data (qualitative and quantitative). Accordingly, this design is considered as the most basic mixed methods design where both qualitative and quantitative data are collected side-by side for confirmation purposes. The key assumption of this strategy is that the qualitative beliefs and the quantitative scores obtained, probably revealed and reflected the same results. Furthermore, both types of data were collected using the equivalent or parallel variables, which means that the same focus was given during the interview setting and the questionnaire as well (Creswell 2014). Thus, the interview questions emphasized the impact of E-STEM model on students' outcomes, and the students' questionnaire identified both the E-STEM practices and entrepreneurial competencies (outcomes) to test the relationship between them. Although the two types of data were collected at the same time, they were analysed separately to compare their results in order to confirm or reject the assumption (Creswell 2014).

Accordingly, the developed E-STEM model was implemented for two academic terms with grade 10 and 11 students under the supervision of five teachers who have long teaching experience in science, math, technology, engineering and business and who teach the same high school classes. After the implementation, data was collected in two phases (qualitative and quantitative) concurrently to test the E-STEM model that was implemented in a six-month period with secondary students in one of the public schools in Ajman that applies the unified-STEM curriculum. The five participating teachers were teaching the same five classes that contain 113 male and female participating students.

Thus, the qualitative phase was carried out after E-STEM implementation to explore the extent to which entrepreneurial-STEM model (E-STEM) contributes to the entrepreneurial learning in terms of students' outcomes based of teachers' perceptions. One focus group interview (Appendix 6) was conducted with three of the participating STEM teachers (science, technology and business) who were recruited voluntarily as a purposive sample

(Fraenkel & Wallen 2012) from those who implemented the developed model with secondary students. Whereas, the other two teachers (engineering and math) were not able to attend the interview and responded to its questions by email. Despite this small sample size (5 teachers), the intent of collecting the interview data was achieved, which is to locate extensive information that reflects an in-depth perspective from this small sample whom volunteered to implement the E-STEM model in their classes. Consequently, the qualitative data was summarized and interpreted to provide meaningful results.

Meanwhile, the quantitative data in this stage was conducted through a quasi-experimental approach that aims to find “cause-and-effect relationships among variables” (Fraenkel, Wallen & Hyun 2012, p.265). Accordingly, this phase focused on the cause and effect relationship between E-STEM practices (independent variables) and students’ entrepreneurial competencies (dependent variables) that were measured and compared between both control and experimental groups (Fraenkel et al. 2012). Creswell (2012) defined the quasi-experimental as “experimental situations in which the researcher assigns, but not randomly, participants to groups because the experimenter cannot artificially create groups for the experiment” (p.626). Moreover, Johnson and Christensen (2014) explained that quasi-experimental research design is adopted when the researcher does not have the ability to fully control the potentially confounding variables primarily because it was difficult to assign subjects randomly to comparison groups.

It was not possible to randomly assign students for either the experimental or control group because it was inappropriate to regroup the classes that were located earlier by the school and the system does not provide permission to reassign students to different classes for the study purpose. This means that it was a necessity to conduct the research experiment making use of the existing classes of High School students under the supervision of the recruited teachers. In this regard, the five participating teachers explained the E-STEM model to their classes to

be aware of the purpose and requirements of the study. Few students withdrew from the study because E-STEM model is extra work that is not graded or affects their academic scores. These students joined in with the participating students, but they were not included in the inquiry.

The current study involved six classes of high school students that were randomly assigned as intact groups to two groups (experimental and control). Thus, the two groups were matched in terms of initial STEM implementation, so it is reasonable to assume that the results were not due to the effect of STEM. (Johnson & Christensen 2014). Accordingly, the experimental group received the treatment (E-STEM model), where participating STEM students were given scenarios that include engineering problems. Moreover, they were asked to utilize and apply mathematical, technological and scientific methods to solve the problem in an entrepreneurial behaviour and environment through experiential and PjbPS pedagogy. While the control group applied the regular STEM classes without incorporating entrepreneurial practices. Thus, they were asked to work as usual through integrating science, technology, math and engineering knowledge to solve the given problem. Finally, both groups were post-tested on the dependent variables (entrepreneurial competencies including knowledge, skills and attitudes). Fraenkel et al. (2012) called this design “The Matching-Only Pretest-Posttest Control Group Design” (p. 275) where there is no assurance that subjects are equivalent. Moreover, participating students in each group have been matched (on certain variables) but not randomly assigned to the groups. Further, Johnson and Christensen mentioned that this design is also called a “non-equivalent comparison-group design [that is defined as a] design consisting of an experimental group and a non-equivalent untreated comparison group, both of which are administered pre-test and post-test measures”

(p. 358). The following figure shows the Matching-Only Pre-test-Post-test control Group Design.

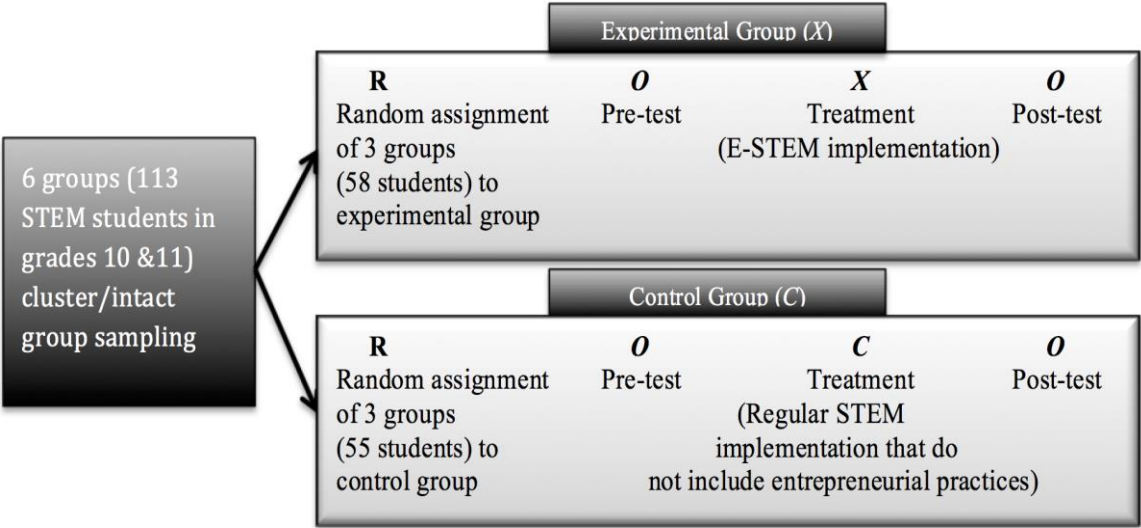


Figure 12: The Matching-Only Pretest-Posttest Control Group Design

Figure 12 illustrates the path of the quasi-experimental design through pre and post-test measurements, where three classes were randomly assigned to take the pre-test, apply E-STEM, then post-test. Meanwhile, another three classes were randomly assigned to take the same pre-test, apply regular STEM, then the same post-test.

Thus, a paper-based questionnaire (Appendix 8) is considered as a quantitative tool or the test that was given twice (pre and post) to both the 58 students who implemented the E-STEM model and 55 students who did not implement the same E-STEM model instead they were working in the regular STEM classes. The purpose of this test is to investigate the relationship between E-STEM practices and students’ entrepreneurial competencies through asking students about the practices they applied and the competencies they developed. The analysis of the quantitative database was conducted separately to compare the mean scores of the pre-test and post-test by using SPSS, and then compared to the qualitative findings that

were collected at the same time to test the study hypothesis. The following figure shows the stages of the convergent parallel mixed methods design.

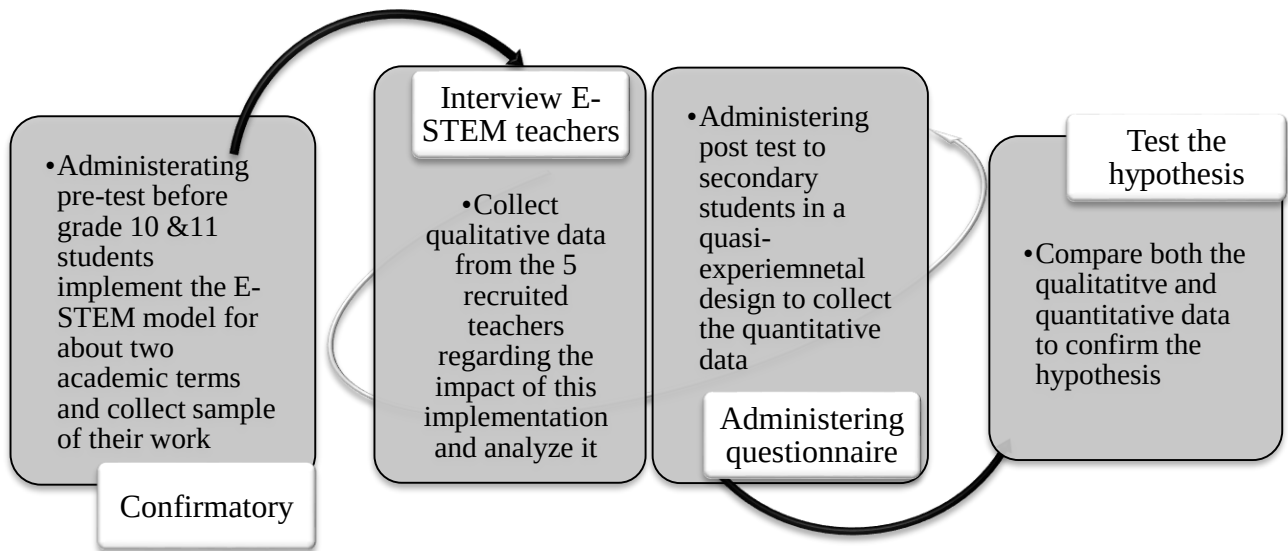


Figure 13: Stages of the Convergent Parallel Mixed Methods Design

Figure 13 illustrates the sequence of the convergent parallel stages that was conducted in the confirmatory stage of the study. A questionnaire (pre-test) was administered to the recruited students. Then, after the implementation of the E-STEM model, an interview was conducted for E-STEM teachers side-by-side with the post-test for the two groups of students to gain more breadth and depth of understanding about teachers' perceptions of E-STEM implementation, and to examine the relationship between E-STEM practices and students' entrepreneurial competencies. More details are also explained about each instrument as follows

Instrumentation of the Confirmatory Stage

The confirmatory stage contains two different instruments that were conducted concurrently. The first instrument is a questionnaire distributed to teachers who participated in the implementation of E-STEM model to investigate their perceptions regarding the impact of E-STEM model practices. The second instrument is the questionnaire distributed to students who implemented E-STEM model to examine the relationship between E-STEM practices and entrepreneurial practices of students. The following section provides detailed information about the structure of the instruments conducted at this stage.

E-STEM Teacher Interviews

Creswell (2013) clarified that the key idea behind using a qualitative instrument is to learn more deeply about the research problem from the contributors, at the same time as having the flexibility to be engaged in the best way to elicit the required information. That is why; the qualitative process follows an emergent design where proposed phases can be manipulated, and prepared questions could be changed to best address the situation. Thus, after the implementation of E-STEM model that took about two academic terms to produce results, the five recruited teachers who implemented the model in their classes were called for interview. Hence, Johnson & Christensen (2014) defined the focus group as, “a moderator leads a discussion with a small number of people” (p. 234). The five participants were purposefully selected because they implemented the E-STEM model and they can provide the information of interest to the study. Three of the participating teachers were able to attend a face-to face meeting to respond to the semi-structured interview questions that were prepared to guide the path of this focus group interview and to explore their perceptions regarding the impact of applying E-STEM model on students’ entrepreneurial outcomes. However, two of the participating teachers had personal issues that prevent them from attending the meeting, but they responded to the interview questions through emails.

The three main principles' of Schensul et al. (1999) were taken into consideration to maintain the interview quality through considering the accuracy of questions, positive relations with participants and being an uninvolved member to avoid bias. The focus group interview with the three teachers extended for about 70 minutes in length where five open-ended questions were designed to keep the group focused on the phenomenon being discussed (Jonson & Christensen 2014).

An educational expert reviewed the interview protocol to promote its content validity and his feedback was effective in modifying and avoiding any leading questions (Creswell 2014). Furthermore, the transcript of the interview responses was given to another academic researcher to enhance inter-coding reliability through coding the first two questions. After discussion and agreement was achieved, the main themes were identified to analyze and interpret the qualitative responses more effectively (Krippendorff 2004). Generally, all data was summarized and interpreted to compare the qualitative findings with the quantitative data.

E-STEM Student Questionnaire

The questionnaire consists of three quantitative sections with close-ended elements. The first section presents the demographic information of the students such as gender and grade. The second section seeks to elicit perceptions on how much emphasis was placed on the main practices used in the E-STEM model where the practices were identified earlier in the STEM teachers' questionnaire and the reliability of this section was measured with Cronbach's alpha .768. Besides, when conducting factor analysis test, both the variables (PBL/ PjBL practices and value creation practices were loaded in one factor). Accordingly, this section gathered them under the name of E-STEM practices where 17 closed-ended items were measured by the 5-point Likert scale to explain the emphasis of applying each of them in the implementation stage of the model.

Finally, the last section focuses on the cognitive and non-cognitive competencies of students that were developed during the E-STEM implementation. This section is divided into three variables (knowledge, skills and attitudes) where the number of items of each one of them is (5,10,5) respectively. The questionnaire was developed from the literature of both EE and STEM education. Elements of the section that represent the entrepreneurial competencies of students were modified from the questionnaire conducted by Tsakiridou & Stergiou (2014) and another questionnaire conducted by Kyndt & Baert (2015). In this regard, inferential statistics were used through SPSS database to identify the relationship between the independent variable (E-STEM practices) and the dependent variable (students' entrepreneurial competencies).

The paper-based questionnaire was distributed twice manually to all the 113 recruited students (experimental and control) in their STEM classes to explain their perceptions regarding the relationship between E-STEM practices that were emphasized as a treatment and the entrepreneurial competencies that were developed. The following table shows the fully anchored rating scale that was used in the students' questionnaire.

Table 8: Likert Scale Used for each Cluster in the Developed Questionnaire of E-STEM Students

Variable	Items	Dimensions	Questionnaire Answer Options				
			5	4	3	2	1
Effective Practices	Questions 1 to 17	E-STEM Practices	Always applied	Often applied	Occasionally applied	Rarely applied	Never applied
Students' Entrepreneurial Competencies	Questions 18 to 22	Knowledge	Strongly agree	Agree	Neutral	Strongly disagree	Disagree
	Questions 23 to 32	Skills	Strongly agree	Agree	Neutral	Strongly disagree	Disagree
	Questions 33 to 37	Attitude	Strongly agree	Agree	Neutral	Strongly disagree	Disagree

Table 8 shows the Likert scale used in the developed questionnaire of E-STEM students where (5= always applied, 4=often applied, 3= occasionally applied, 2= rarely applied and 1= never applied).

Validity and Reliability of E-STEM Student Questionnaire

The following section provides detailed information about how validity and reliability of the questionnaire provided to students were assessed.

Validity of E-STEM Student Questionnaire

Fraenkel et al. (2012) explained that relating the variables measured to another instrument that was conducted and assessed before is a good way to promote truthfulness of the instrument because it enhances the criterion-related evidence of validity. In this essence, the three factors of the entrepreneurial competencies of the students (knowledge, skills and attitude) were adopted from the questionnaire conducted by Kyndt & Baert (2015) who used equivalent set entrepreneurial competencies that considered in the literature as essential characteristics for future entrepreneurs and the psychometric quality of this instrument was assessed and its reliability coefficient ranged between .60 and .87. Moreover, the confirmatory factor analysis assessed the convergent validity of the tool as well as the discriminant validity and all were accepted. Furthermore, the construct validity was considered by comparing the mean scores of both experienced and aspiring “was significant (Pillai's trace = .03, $F = 20.18$, $df = 2, 15,723$, $p < .001$)” (p. 17). Accordingly, comparing the performance of the instrument being validated by Kyndt & Baert (2015) with the performance of the current adopted instrument enhances its validity.

In addition to that, Creswell (2009) explained “experimental procedures, treatments, or experiences of the participants that threaten the researcher’s ability to draw correct inferences

from the data about the population in an experiment”(p.162) are all considered as internal validity threats of the non-equivalent comparison-group design because it is more susceptible to obtain biased outcomes than true experimental designs. In this regard, the meta-analysis conducted by Heinsman & Sadish (1996) to investigate the effect size estimates from studies conducted by strong experiments (random assignment of participants) and quasi-experiments found that the effect size of them would be equal, only if they both well performed and designed.

The internal validity of the instrument concentrated on testing what E-STEM model was supposed to assess. Therefore, a key concern was emphasized to control confounding variables and maximize the probability of unbiased inferences. This concern deals with how secondary students were assigned to groups. As it was not an option to assign students randomly to two groups, intact groups of the six classes were assigned randomly to different treatments. In other words, the random assignment of groups was an alternative option to random assignment of participants. Then, E-STEM model was given to experimental group and regular STEM curriculum was applied with the control group. Finally, students in each treatment were statistically matched with their peers in the other treatment (Fraenkel et al. 2012).

Accordingly, expected-potential threats of this design were carefully identified to minimize as many as possible. For example: all participating students from grade 10 and 11 are the same age (between 15 and 16 years old), which means they mature or change at the same rate during the inquiry. Moreover, to avoid withdrawal as an internal threat, an adequate number of participants (128 secondary students) were recruited to account for dropout (15 withdrew). Accordingly, the study was conducted with 113 respondents of secondary students. Furthermore, diffusion of treatment was also avoided by keeping the two groups separate in different classes during the experiment. Furthermore, a long-time interval was considered in

order to not to allow students to become familiar with the test that was used twice. Generally, Fraenkel et al. (2012) confirmed that collecting data through the design of matching-only pre-test-post-test control group is mostly effective in controlling many of the internal threats such as history, regression, mortality, maturation, subject characteristics, instrument decay and testing.

Meanwhile, the average mean of the communalities was .7 and this promotes determining the factors of the students' questionnaire by factor analysis test (Appendix 12). The results reflected the majority of items of the independent variable E-STEM loaded in component 3, while items of the dependent variable (knowledge) were loaded equally in both component 2 and 3. Similarly, items of skills were loaded equally in both 1 and 2 components. Finally, items of attitude loaded mostly in component 4. These results indicate that the four variables can be separated in four factors. However, the components matrix conducted for the variables (knowledge, skills and attitude) with 1 component extracted can be seen in the following table.

Table 9: Component Matrix of the Dependent Variables of the Study

Dependent Variables	Component (1 factor)
Knowledge	.810
Skills	.870
Attitude	.731
Extraction Method: Principal Component Analysis. a. 1 component extracted.	

Table 9 indicates that the three variables (knowledge, skills and attitude) could be combined in one factor named entrepreneurial competencies. On the other hand, the external validity concentrated on the probability of generalizing the impact of implementing E-STEM model to the population of the inquiry. In respect to the external validity threats, Creswell (2009)

mentioned that these threats “arise when experimenters draw incorrect inferences from the same data to other person, other settings, and past or future situations” (p.162). Thus, the location in Ajman branch was constant throughout the experiment as one of the schools under the same organization around the UAE that all implement a unified STEM curriculum and the results of this experiment could be generalized among STEM students in high schools in the UAE.

Factor Analysis

Factor analysis is a, “technique that allows a researcher to determine if any variables can be described by few factors” (Fraenkel et al. 2015, p.338). Exploratory Factor Analysis is often used “to investigate whether there is an underlying structure in the pattern of correlations between a number of variables” (Brace, Kemp & Snelgar 2016). Thus, a factor analysis test was conducted to promote the validity of items that form each proposed variable. Additionally, this test is used to ensure that each factor represents what it is assumed to measure.

Table 10: Results of Factor Analysis

Rotated Component Matrix					
Items of each Variable		Component			
		1	2	3	4
Q1	Item 1: E-STEM Practices	.681	-.129	.131	.032
Q2	Item 2: E-STEM Practices	.261	.096	.302	.190
Q3	Item 3: E-STEM Practices	.301	.010	.457	.086
Q4	Item 4: E-STEM Practices	.641	-.048	.234	.208
Q5	Item 5: E-STEM Practices	.208	.243	.542	-.114
Q6	Item 6: E-STEM Practices	.070	-.149	.436	.324
Q7	Item 7: E-STEM Practices	.061	.045	-.002	.301
Q8	Item 8: E-STEM Practices	.017	.045	.558	.254
Q9	Item 9: E-STEM Practices	.108	.048	.724	.166
Q10	Item 10: E-STEM Practices	.490	.277	-.027	.075
Q11	Item 11: E-STEM Practices	.143	.217	.361	-.014
Q12	Item 12: E-STEM Practices	.680	.229	.205	-.044
Q13	Item 13: E-STEM Practices	.767	-.028	-.133	.158
Q14	Item 14: E-STEM Practices	-.044	.028	.145	.102
Q15	Item 15: E-STEM Practices	.161	-.034	.526	-.120
Q16	Item 16: E-STEM Practices	-.115	-.136	.633	.328
Q17	Item 17: E-STEM Practices	.016	.055	.464	.093
Q18	Item 1: Knowledge Cognitive	.308	.813	.155	.012
Q19	Item 2: Knowledge Cognitive	.184	.225	.613	.054
Q20	Item 3: Knowledge Cognitive	.552	.164	.279	.019
Q21	Item 4: Knowledge Cognitive	.063	.178	.609	-.086
Q22	Item 5: Knowledge Cognitive	.200	.890	.174	.097
Q23	Item 1: Skills Cognitive	.170	.276	.288	.393
Q24	Item 2: Skills Cognitive	.087	.931	.141	.148
Q25	Item 3: Skills Cognitive	.511	.262	.072	-.024
Q26	Item 4: Skills Cognitive	.493	.179	.142	.024
Q27	Item 5: Skills Cognitive	.292	.274	-.069	.309
Q28	Item 6: Skills Non-Cognitive	.726	.085	.090	-.125
Q29	Item 7: Skills Non-Cognitive	.038	.416	.024	.290
Q30	Item 8: Skills Non-Cognitive	-.054	.070	.135	.569
Q31	Item 9: Skills Non-Cognitive	.726	.085	.090	-.125
Q32	Item 10: Skills Non-Cognitive	.087	.931	.141	.148
Q33	Item 1: Attitude Non-Cognitive	.571	.108	-.020	.271
Q34	Item 2: Attitude Non-Cognitive	.005	.148	.184	.817
Q35	Item 3: Attitude Non-Cognitive	-.007	.041	-.038	.800
Q36	Item 4: Attitude Non-Cognitive	.222	.104	.351	.653
Q37	Item 5: Attitude Non-Cognitive	.422	.015	.193	.332
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 6 iterations.					

The results presented in the table 10 indicate that each item is loaded in a separate component.

Firstly, twelve items from the first variable (E-STEM practices) that contains seventeen items

loaded in component 3. For the second variable (knowledge), two items loaded in component 2 and another two in component 3. Since the first variable loaded in 3, so component 2 is chosen to represent second variable. The third variable is the (skills), both cognitive and non-cognitive loaded in component 1. Lastly, variable 4 is the (attitude) loaded in component 4. According to this result, there is one independent variable, which is the (E-STEM practices). Moreover, three independent variables are validated (1) knowledge, (2) skills and (3) attitude. The direct hypothesis proposed in this study is that E-STEM practices can positively enhance students' entrepreneurial competencies including; knowledge, skills and attitude.

Reliability of the E-STEM Students Questionnaire

Johnson & Christensen (2014) explained that a pilot test is a, “Preliminary test of your questionnaire” (p. 212). It is an essential test to help determine whether the instrument operates properly before conducting it in the main research study. Thus, Cronbach alpha coefficient was measured for all items of the questionnaire and for each cluster through the pre-test sitting to assess the internal consistency of scores. First, the following table shows the values of the Cronbach's alpha of all variables of the questionnaire (pre-test).

Table 11: Cronbach's Alpha Coefficient of the Test-Retest Administration of Students' Questionnaire

Internal Consistency of scores		
Dimensions (Variables)	No. Of items	Alpha coefficient
E-STEM Practices	17	0.732
Knowledge	5	0.707
Skills	10	0.720
Attitude	5	0.734
Total score	37	0.874

Table 11 shows that the values of Cronbach's Alpha of the proposed variables were above .07, which reflect good reliability of all clusters being developed. The total score of internal consistency of the questionnaire is relatively high (.874) that enhances the reliability of the students' instrument and reflects that its components are accepted for the study.

For more reliability emphasis, Kuder-Richardson (KR-20) is the most frequently employed method to determine the internal consistency that estimates reliability among dichotomous values (Fraenkel et al. 2012). Thus, items of the main four variables were computed and then the scores of all computed variables were changed from continuous to categorical variables using SPSS and divided into two groups. Accordingly, the Cronbach's Alpha coefficient was calculated for the four main categorical variables. In this regard, the value obtained was .755, (Appendix 11), which confirms a good level of internal consistency of the questionnaire.

The reliability test of the post-test (students' questionnaire) was assessed through measuring Cronbach alpha coefficient. Accordingly, the questionnaire was given to the students after the implementation of the E-STEM model and the value of its Cronbach's alpha coefficient (.885) indicated high reliability. The following table indicates the internal consistency of each variable of the students' questionnaire.

Table 12: Values of Cronbach's Alpha Coefficient of the Variables in the Students' Questionnaire

Dimensions (Variables)	No. Of items	Alpha coefficient
E-STEM Practices	17	0.759
Knowledge	5	0.722
Skills	10	0.717
Attitude	5	0.721
Total score	37	0.885

Table 12 illustrates that the scores of Alpha coefficients of each variable are above 0.7 and the total value of the Cronbach's alpha coefficient of all items of the questionnaire is .885. This

reflects high stability of the mean if compared to the internal consistency measured for the same test before the E-STEM implementation with score (.874).

3.3 Data Analysis

Both qualitative and quantitative types of data were analysed separately. Methods of data analysis were selected based on the nature of each type. The following sections give more detailed information about how each type of data was analysed to answer the study questions.

3.3.1 Qualitative Data Analysis

Analysing the qualitative data collected from the constructivist grounded theory began immediately with initial contact with STEM academic leaders to explore first variables of the phenomenon being studied. Then it continues with the progress of the grounded theory development, which means that activities of gathering qualitative data and analysing them were continual and concurrent. The common method in analyzing data collected from a grounded theory is called “the constant comparative method” (Johnson & Christensen 2014, p. 460) where similarities and differences are identified in an ongoing process. Thus, the qualitative analyst who is committed to the naturalistic perspective becomes more sensitive to what kind of information needs to be focused on and what aspects of the obtained data are the most essential to facilitate developing the theory that meet the criteria of the grounded theory (fit, understandable, generality and control). In this respect, Johnson & Christensen (2014) described this theoretical sensitivity as, “A mixture of analytic thinking ability, curiosity, and creativity” (p. 460).

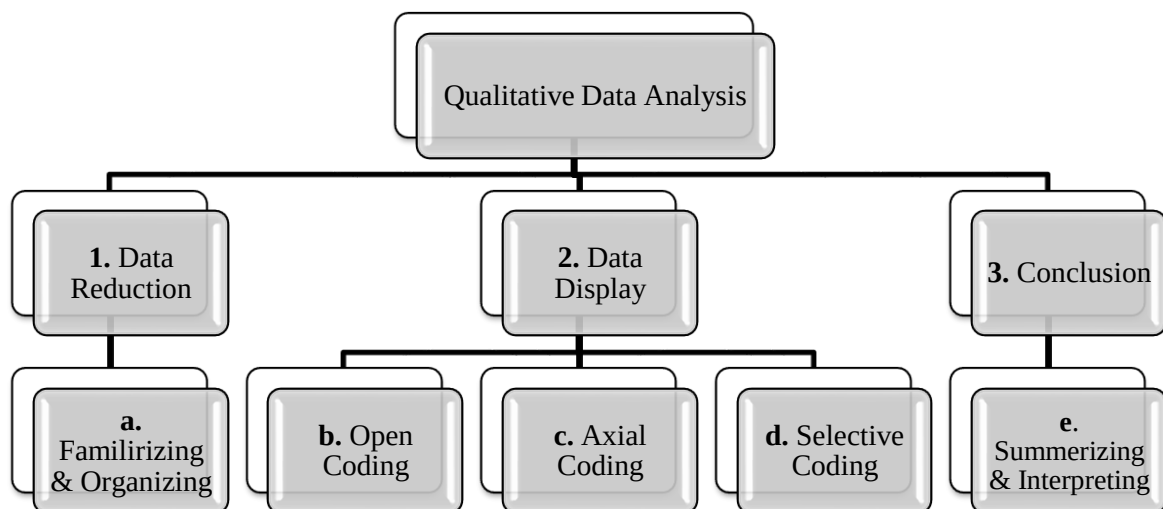
Codes of Participants

Moreover, codes were created to discuss the views of the interview participants with full respect to their anonymity as follow:

- Academic lead teachers of each STEM disciplines named ‘STEM academic leads’
- Teachers implemented E-STEM model named ‘E-STEM teachers’
- Science lead teachers were coded (SL) - Science teacher (ST)
- Technology lead teachers were coded (TL) - Technology teacher (TT)
- Engineering lead teachers were coded (EL) - Engineering teacher (ET)
- Math lead teachers were coded (ML) - Math teacher (MT)
- Business lead teachers were coded (BL) - Business teacher (BT)
- Curriculum Developer was coded (CD)

In order to move forward from the initial exploratory database to the instrument or scale development, quotes, codes and themes that are produced in the interview were considered. The development of STEM teachers' questionnaire proceeded by using the quotes to identify certain items for the questionnaire. Moreover, the codes were condensed to develop the main variables that group the previous items. Then codes were categorized by identifying the highlighted themes. Accordingly, the theoretical model generated in the grounded theory help to provide a new educational model (E-STEM) to be tested in the next design.

Miles & Huberman (1994) adopted a systematic approach with an interactive model to analyze the qualitative data. The model consists of three fundamental components that are data reduction, data display and drawing/verifying conclusion that were used to analyze the initial



data set from the academic leaders' interview in order to display it in the form of questionnaire to be conducted in the second stage of data collection. The ongoing analysis process of qualitative data was conducted concurrently with the data collection in order to have continual reflection. The following figure illustrates the strategies used to analyze the qualitative data obtained in the study.

Figure 14: Strategies Applied to Analyze Qualitative Data

Figure 14 demonstrates the linear and hierarchical approach of qualitative data analysis adopted in the current study as it was derived by both Miles & Huberman (1994) and Creswell (2009). However, qualitative data analysis is an interactive practice that requires going back-and-forth throughout the data. The previous stages presented in the figure were interrelated and sometimes during the analysis, they could not be located in the same order. Moreover, the exploratory perspective supports considering all the ideas and codes that might form or identify any new or unexpected themes in what is called a thematic framework analysis (Attride-Stirling 2001).

- **Data Reduction:**

Reducing the data is the first form of qualitative analysis that focuses on the analytic choices that discard, sharpen and organize the obtained data to be more condensed through identifying the most meaningful quotes. It was essential to be familiarized with the material through reading and re-reading to obtain a general sense about the overall meaning, making useful notes in margins to summarize or reduce the transcript. Thus, scribing the interview questions help in organizing the raw data transcript into new field notes to clarify the holistic idea (Creswell 2009).

- **Data Display**

The second stage in analyzing the qualitative data is the process of the data display, which required coding and recoding the data in three different levels. The main aim of this stage was to identify the key codes and themes that represent the variables to be used for the development of the STEM teachers' instrument. Thus, the first level of the coding process is called open coding where sentences that focus on incorporating entrepreneurial practices into STEM education were identified and grouped in categories around the core phenomenon under investigation. Scanning the material many times was helpful to decide on what types of categories were found in the data. Strauss & Corbin (1990) prescribed four main categories that can be identified such as causal condition, strategies, intervening and consequences that all focus on the core problem of the study. Each group of open codes (quotes) formed a category that was arranged in a table in the second level (axial coding). Finally, categories or tables were

grouped further and interrelated to develop propositions in the last level of coding (selective coding) as it is represented in the following table.

Figure 15: Actual Example of the Three Levels of Coding Applied in the Study

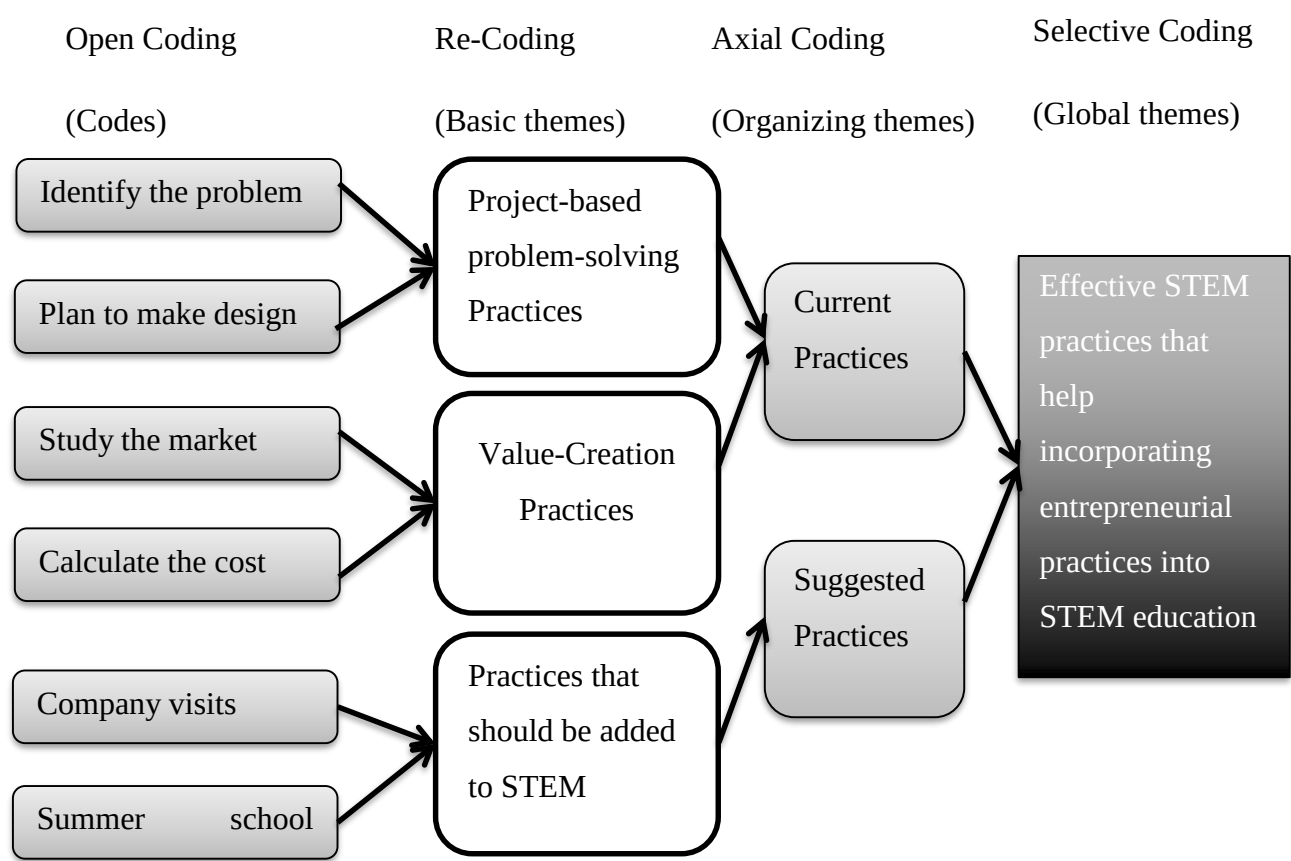


Figure 15 demonstrates an actual example of the three levels of coding that occurred during the analysis of the qualitative data collected from the interview of the academic leaders. According to the previous coding system, all the qualitative data were analyzed and organized in clusters and displayed in tables to develop the questionnaire needed to expand the results among the larger population of STEM teachers to confirm the information obtained and achieve better understanding of the research problem. This integration between different approaches means that the data were mixed through being connected between the analysis of

qualitative data and the collection of the quantitative data (Creswell 2009). In light of Strauss and Corbin's categories, two main relevant categories were generated from the qualitative data through identifying the main themes, which are:

- Category of strategies: that represents the action taken or the practices applied to enhance the core phenomenon (incorporating entrepreneurial practices into STEM education), which named, effective practices that include current practices and suggested practices as well.
- Category of contextual and intervening conditions: that represents the situational factors that can affect the strategies of the core problem, which named, challenges of the incorporation.

- **Conclusion Drawing & Verification**

In the last stream of qualitative data analysis, the obtained data was summarized in an understandable manner and introduced in tables to highlight the common agreement and shared views of participants in the following chapter. The same process of analysis was implemented for all qualitative data gathered in the study including, educational leaders' interview, the open-ended questions attached to the STEM teachers' questionnaire, and the E-STEM teachers' interview as well. Thus, the conclusion was continual and verified as the process of the analysis proceeds because constructing meaning from attained data started from the first contact with the work field. Thus, all notes take during collecting the qualitative data were kept as well as explanations, pattern and propositions to maintain skepticism. However, the final conclusion could not be reached until the whole process of data collection is over. Furthermore, verification was achieved through review and long discussions with colleagues and other educational researchers to develop consensus about the results. Moreover, the

negotiated agreement with the other coder was adopted to solve any discrepancies as discussed earlier in the section of the reliability of the interview data (Cohen, Manion & Morrision 2000).

With regards to the qualitative data collected in the exploratory sequential design, it was analyzed separately and then connected to the quantitative data collection, where the variables identified from the qualitative interview data were used to develop the STEM teachers' questionnaire of the quantitative data collection. Whereas, the qualitative data collected (E-STEM teachers) through the convergent parallel design was merged to the quantitative data (E-STEM students) where both of them analyzed separately and converged through a "side-by-side comparison" (Creswell 2014, p. 222) in order to discuss the obtained results.

3.3.2 Quantitative Data Analysis

Both descriptive and inferential statistics were employed through the Statistical Package for Social Sciences (SPSS, version 23) to achieve the best meaningful conclusion from the obtained data. Both reliability and validity tests were measured to assess the internal consistency as well as the trustworthiness of the data provided by teachers' and students' questionnaires.

The quantitative data of the teachers' questionnaire was analysed through measuring the mean and standard deviation of all items of the instrument to answer the second and third study questions. Furthermore, an examination of differences was applied among the main five demographic variables in the instrument, including: The Emirate, gender of the participant, the highest academic qualification achieved, years of teaching experience and the subject taught. Meanwhile, the distribution of scores, homogeneity of variances and then One-Way ANOVA test were conducted to compare mean scores among groups. Thus, when the scores are normally distributed, Levene's test verified the equality of variances in the samples where homogeneity of variances $p > 0.05$ (Martin & Bridgmon 2012). On the other hand, if the distribution of scores is not normal, the new non-parametric Levene's test is employed (Nordstokke, Zumbo, Cairns

& Saklofske 2011). Levene's test is often used before a comparison of means to verify the assumption that mean scores of variables have equal variances ($p > .05$) (Levene 1960). Consequently, ANOVA test informs whether there is an overall difference between mean scores of variables among the groups. However, the group with significant difference is not identified by this test (Field 2018). Accordingly, Post Hoc test is important to determine the exact groups that have a significance difference between their scores (Field 2018).

Regarding the quantitative data of the students' questionnaire. Confirmatory factor analysis was conducted to determine the number of variables that are loaded in each factor, which ensure the validity of elements that form the clusters of variables (Fraenkel et al. 2012).

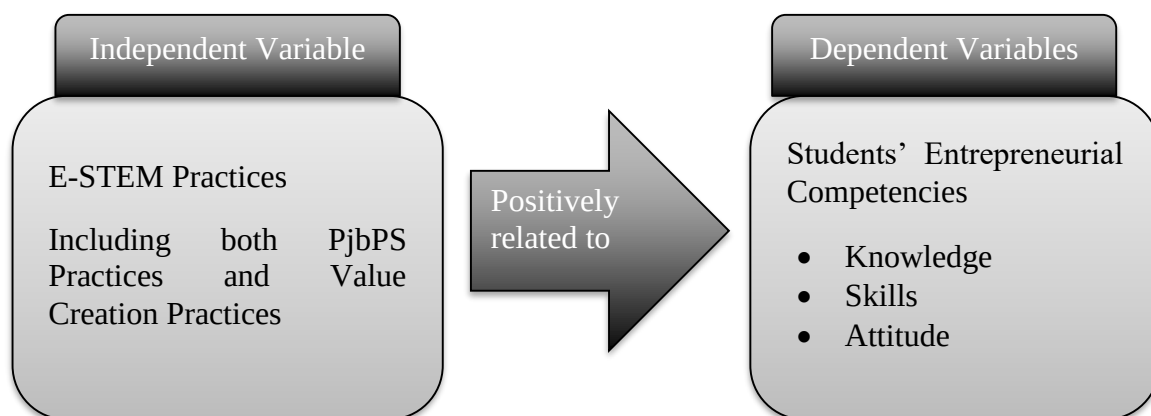


Figure 16: Theoretical Hypothesis of the Quantitative Study

Figure 16 identifies the two main variables of the study (E-STEM practices) as an independent variable and (entrepreneurial competencies that include knowledge, skills and attitude) as a dependent variable. Based on the literatures of entrepreneurial education as well as STEM education and relying on the theoretical framework discussed in chapter 2, the current study hypothesized directly that implementing the practices of E-STEM model would positively relate to the acquisition of entrepreneurial competencies of STEM students. The variable of E-STEM practices is a one-dimensional independent variable because both project-based problem

solving, and value creation practices were loaded in one factor. However, the entrepreneurial competencies of students included three categories (knowledge, skills and attitude) that were loaded in three different factors. Thus, mean scores from both the control group and experimental group were compared by independent t-test to confirm the study hypothesis (Foster 2001).

3.4 Ethical Considerations

The current study was conducted ethically. Moral contemplations were precisely assessed to ensure the respect and anonymity of all participant members and the legitimacy of the investigation in general. Thus, a school consent letter (Appendix 1) was given to the educational organization that implement STEM education to be provided with a satisfactory explanation of the main purpose, objectives of the study and its methodology in order to enhance research accessibility (Creswell 2009). Accordingly, emails were sent to many academic leaders in the branches of the organisation being selected for the study in order to be aware of their policies and obligations and to facilitate the data collection and distribute the questionnaires to the target participants. Moreover, participating teachers and leaders in the qualitative phases of the study were informed of all the aspects and the features of the inquiry including the significance of this investigation to promote their willingness to participate and to encourage them to honestly answer the given questions. Thus, the interviewees signed a consent form (Appendix 2) prior to the study for the review board where an adequate level of confidentiality was ensured. Furthermore, the purpose, objective, time needed, the plan for using the results obtained by the interview were all explained at the beginning of each meeting to ensure transparency during communication and to explain the possible implications of the study. Furthermore, responsibilities of both the respondents and the researcher were clarified and agreed with respect to the dignity of the participants (Creswell 2014). In respect to the quantitative instruments, all elements do not refer to any of the sensitive issues or psychological problems

and participants are not subjected to any harm. Moreover, it was written in the questionnaire that all participations are totally voluntary, and the contribution of respondents is highly appreciated. After the implementation of E-STEM model, some of the volunteered STEM teachers were interviewed in a face-to-face meeting and all the rights were clarified and discussed before signing the consent form (Appendix 5). Additionally, high school students were informed about the purpose of the project and all its requirements. It was also assured that their participation was not obligatory, and they have the right to proceed or withdraw any time during the process of the research. Accordingly, students' representatives from both girls' and boys' classes signed the consent form (Appendix 7) that was read to the participating classes. Furthermore, it was confirmed to them that their coursework grades would not be affected by the E-STEM implementation. Accordingly, six classes were willing to contribute to the research without the exercise of any coercion or pressure, and then their classes were assigned randomly to two groups. However, a few of the students recruited to participate in the study did not have the desire to respond to the piloting questionnaire and their choice was respected. Moreover, some students withdrew during the implementation because they had insufficient time to work on their regular school assignments. Additionally, anonymity was kept confidential and all the participants had the right to refuse or even withdraw from contributing to the study (Fraenkel & Wallen 2012). They were informed that their original identity would not be used or announced instead the sequence of cases or subject taught would be used to refer to participants to enhance their willingness to proceed. Techniques of data collection that might cause undesirable consequences or harm to any of the participants were manipulated and minimized. For example: none of the participants attempted to record the interview by video or audio means. Another scholar was recruited to take notes and type the manuscript in order to make all the respondents more comfortable and freer to express their beliefs (Johnson & Christensen 2014).

3.5 Summary

The current study was conducted through a mixed methods approach where both qualitative and quantitative data in a multiphase project were required to reach appropriate and reasonable conclusions that fully answer the research questions. Thus, in the first sequential design, the two types of data were collected to complement each other. The qualitative phase identified the main variables needed to incorporate entrepreneurial practices into STEM education. Data was analysed and used to develop a new questionnaire for STEM teachers to expand the information and gain more breadth of understanding of the phenomenon under investigation. Then the two types of data were interpreted to develop the E-STEM model to be tested in the second research design. By this method, the advantages of each way of data collection to a large degree mitigate the disadvantages of the other. In order to test the new educational model (E-STEM), a convergent parallel design was selected where again the two types of data were collected concurrently to inform aspects related to the larger research questions addressed by the study. Thus, quantitative data was collected through a non-equivalent comparison group as a common type of a quasi-experimental design where intact groups of high school students were randomly assigned to experimental and control groups. Only experimental group applied the E-STEM model. The same questionnaire was given to the two groups before and after the implementation to compare their mean scores. Afterwards, qualitative data was collected through a focus group interview with the E-STEM teachers who implemented the model in their classes. Both the qualitative and quantitative data were merged to draw reasonable conclusions that reflect the relationship between E-STEM practices and entrepreneurial competencies of students. In this regard, validity and reliability consideration of all the instruments used in the study were addressed as possible to enhance the obtained results. Finally, all ethical dilemmas were manipulated to motivate participants to honestly and freely contribute to this investigation.

CHAPTER 4: DATA ANALYSIS AND RESULTS

Introduction

The methodological approach and overall strategies that were utilized to conduct the current research are outlined in the previous chapter. Thus, this chapter presents how the collected data of the study is fully analysed and presented. The multifold purpose of the study includes (1) to explore educational leaders' views about incorporating entrepreneurial practices into STEM education, (2) to investigate the effective entrepreneurial practices within STEM classes that enhance incorporating entrepreneurial practices into STEM education as well as the challenges of successful incorporation, (3) to investigate participating teachers' demographics variables in relation to incorporating entrepreneurial practices into STEM education, (4) to develop a model of an entrepreneurial-STEM education (E-STEM), (5) to explore E-STEM teachers' beliefs regarding the impact of implementing E-STEM model on students' learning outcomes, and (6) to examine the effect of E-STEM practices on students' entrepreneurial competencies. The purpose of the study derives the main approach used to conduct the proposed inquiry. While the progression of the study helped determine the most appropriate design in each stage. A multiphase mixed-method approach that includes both qualitative and quantitative research tools was carried out through two research designs to achieve the study objectives. The following questions were posted to explore and explain stakeholders' perceptions about the proposed infusion of entrepreneurial practices into STEM education.

1. What are the educational leaders' views about the incorporation of entrepreneurial practices into STEM education in the UAE?
2. What are the effective practices within STEM education that enhance the incorporation of entrepreneurial practices into STEM education in the UAE?
3. What are the main challenges that might prevent incorporating entrepreneurial practices into STEM education in the UAE?

4. Are there any different responses of participating teachers based on their demographics regarding incorporating entrepreneurial practices into STEM education?
5. What beliefs do E-STEM teachers have regarding the impact of implementing E-STEM model on students' learning outcomes?
6. What is the effect of E-STEM practices on students' entrepreneurial competencies?

Thus, each research question helps determine the best analytical approach to ensure that the data obtained can fully answer this question and effectively address the research problem.

4.1 Results of the Exploratory Stage

Both qualitative and quantitative data were collected through conducting an exploratory sequential design. First, qualitative data was gathered from educational leaders through semi-structured interviews for two focus groups. This data was used to identify the main variables needed to further develop the questionnaire for STEM teachers that represent the second paradigm of this stage. Both the qualitative and quantitative data were interpreted side by side to develop the E-STEM model that incorporates entrepreneurial practices into STEM education.

4.1.1 Results of Educational Leaders Interview

The interview aimed to explore educational leaders' views about infusing entrepreneurial practices into STEM education. Two semi-structured interviews were carried out through two focus group meetings with twelve academic leaders, who were recruited from different branches of the same educational organization in the UAE. The type of data collected is narrative. In the first meeting, seven female leaders volunteered; including lead teachers of mathematics, science, engineering and technology as well as a curriculum developer. Based on the data given at this meeting, two lead teachers from the business department (male and female) were recruited to attend the second meeting that included other academic leaders (females) from math and

technology departments. The interviews were conducted, and the qualitative data obtained was analysed to answer the first research question:

- What are educational leaders' views about the incorporation of entrepreneurial practices into STEM education in the UAE?

Six open-ended questions were asked in the interviews. Only two of the participating leaders were able to differentiate and understand the purpose of the second and third questions and respond to both individually. For example: the third question asked about the contribution of STEM education to entrepreneurial learning, while the fourth asked about the impact of STEM education on entrepreneurial learning. Most perceptions reflected difficulty in understanding the intended meaning, and they gave one response to both questions. Accordingly, one interview question was excluded to become five in total and the responses to these questions are combined and introduced together.

The three fundamental stages of Miles & Huberman (1994) were used to analyse the qualitative data. The first stage is the data reduction, where the mass of the data collected should be reduced; Leaders' responses were familiarized and organized to clarify the major ideas that were discussed consistently during the interview session. The second stage is the data display where the results obtained from educational leaders about the incorporation of entrepreneurial practices into STEM education in the UAE were coded and recoded by classifying them into exclusive categories in order to identify the recurrent themes. A table was made to abridge participants' views with respect to the interview questions. The final stage is drawing a conclusion by summarizing and interpreting the achieved outcomes to give the best-meaning overall.

To enhance the internal reliability of the qualitative data analysis, the transcript was given to another academic researcher who worked independently in order to capture the salient themes of at least two questions (Ajzen 1991). A phone discussion followed until an agreement was

reached. A considerable degree of consensus regarding the major themes emerging from data was reached, and it was possible to overlap the selected codes and categories used for interpretation. For example, the study researcher identified the following themes from the first interview question, using the most prevalent responses that reflect leaders' beliefs regarding what they know about entrepreneurial learning: (1) purpose and features, and (2) source of knowledge, while the independent coder suggested the following noticeable themes from the transcript: (1) objectives and characteristics of entrepreneurial learning and (3) reasons of unfamiliarity. The following paragraphs represent the main themes elicited from leaders' responses for each interview question, followed by a table that summarizes this data.

- **Entrepreneurial learning**

Firstly, participants were asked what they know about entrepreneurial learning. Not all interviewed leaders were familiar with the term 'entrepreneurial learning', however, subsequent to portraying the meaning of the concept, it was clear that all lead teachers have ideas about it from different sources.

- **Purpose and features of Entrepreneurial Learning**

The business lead teachers were the participants who were most familiar with entrepreneurship education in general. For example: the BL was able to define entrepreneurial learning precisely and gave examples of its pedagogy and practices that are used in high school. He said, "it is the process of providing students with the concepts and knowledge to acquire the basic skills not only for job creation and recognizing opportunities but also for creating values to the community." Furthermore, BL explained that few activities of entrepreneurial learning are currently implemented under the supervision of the business department in school. Likewise, the TL clarified that, "school usually makes some common activities such as the 'open day' that give students good opportunities to practice business when they work in groups to sell their goods and gain profits. Definitely this requires planning and studying what could be interesting

for other students to buy their products and they calculate the cost as well.” The EL mentioned that members in her family are entrepreneurs and they are her source of knowledge; based on this personal experience, she found that, “Entrepreneurial learning refers to starting a new business idea to introduce interesting products to the market. More simply, it reflects adding new value to anyone. Additionally, it requires a range of activities to develop a business with considering the probability of success and failure.”

- **Source of Knowledge**

On the other hand, the CD noted that, “most schools in Dubai do not focus much on entrepreneurial learning because it is not included in their curriculum. The ML added, “all what I know about this concept is from the media, so I think entrepreneurial learning refers to teaching students how to introduce new products to the market.” All the participating leader teachers agreed that KHDA, ADEC or the Ministry of Education monitor UAE schools, and that the entrepreneurial learning is included only in certain units of the business curriculum. Therefore, most of their information regarding entrepreneurial learning is from personal experiences.

• **Contribution of STEM education**

Secondly, participants were asked about the contribution of STEM education to entrepreneurial learning. Two main themes created from the responses of participating leaders used to analyse the data are (1) competencies and (2) impact of the incorporation.

- Competencies

All participating lead teachers who were from business, mathematics, science, technology and engineering departments believe that STEM practices can assist in accomplishing the learning outcomes of the entrepreneurial activities. Moreover, it can promote the entrepreneurial intention of the students because they usually acquire many competencies in the STEM classes that are essential for entrepreneurial learning. The BL explained that, “both practices of STEM and entrepreneurship education enhance innovation. Add to that, their curricula are highly supported by integrating knowledge from different disciplines, so incorporating their practices will provide dual benefits to learners.” Interestingly, science lead teachers were so proud of their STEM students and identified them as the future inventors; clarifying their opinions they said “During STEM classes, students acquire many primary STEM abilities that all are considered as entrepreneurial competencies, such as critical thinking, problem solving, communication, perseverance, independence, collaboration, creativity and innovation. Many STEM students are inventors, but their inventions are easily lost unless they become able to take them to the market.” The EL defended this perception by saying, “For example, Volta invented the first electric battery so he is an inventor but not an entrepreneur, while Tomas Edison is an entrepreneur because he was able to commercialize and transfer Volta’s invention to the market, which added a great value to society.”

- Impact of Incorporation

With respect to the second theme ‘impact of the incorporation’, the TL agreed that STEM education contributed to students’ acquisition of entrepreneurial competencies and mentioned that, “although self-employment is not a direct aim of STEM education, engaging STEM students in entrepreneurial practices could enhance the impact of education because it will produce a new generation of entrepreneurs who are scientifically, mathematically and

technologically literate, which will upgrade their abilities from being not only inventors to become inventors and entrepreneurs.” Furthermore, ML explained, “STEM students are equipped to solve real life problems and they acquire the knowledge and skills that make them more eligible than their peers to address uncertain situations of an entrepreneurial context.” The SL commented, “I do agree with this incorporation because entrepreneurial learning will contribute to STEM education as well; it will help students to become more selective and they will be able to design more meaningful STEM products”, and she clarified her view by adding, “many of the STEM students decide to make Biofuel in the STEM class, I can tell this choice is more application of knowledge than creation. Besides, it is not highly required in the market. I would rather prefer they use some time to study the market and create new designs that add value than just applying scientific knowledge in STEM classes.” STEM academic leaders also mentioned the purpose of education in this way, for example, the ML concluded, “both types of education share the same objective that is the acquisition of 21st century skills that allow students to be more independent and confident in the workplace, so, STEM students are able to master the entrepreneurial learning’ capabilities faster than other students.”

- **Possibility of Incorporating Entrepreneurial Learning into STEM Education**

Thirdly, responses regarding if entrepreneurial learning can be incorporated into STEM, revealed three main themes that are (1) Involving business, (2) Characteristics of learning environment, (3) Suggested practices. All participating leaders responded positively towards the possibility of incorporating entrepreneurial practices into STEM education in the UAE because both require integrating knowledge from different disciplines through interdisciplinary approach; however, they strongly suggested involving the business department into this process to be responsible for integrating entrepreneurial practices.

- **Involving Business to STEM disciplines**

The BL explained, “incorporating entrepreneurial pedagogy into existing content discipline such as STEM curriculum is more beneficial than being developed as a separate course because this integration is a flexible approach that can be adopted in STEM curriculum as well as integrating entrepreneurial practices into STEM teaching and learning instructions.” Thus, the CD assumed that, “infusing entrepreneurial practices into STEM education for high school students can be successful, only if the focus of STEM education is broadened and expanded to situate STEM practices or curriculum elements within a business context. Moreover, the objective of STEM activities is not limited to the proposed disciplines ‘S, T, E, M’ that form this abbreviation. Thus, knowledge and application among new academic disciplines can also be engaged effectively.” Accordingly, the other BL added, “entrepreneurial learning can be done in any academic discipline, which makes STEM classes one of the best contexts because it relies on integrated courses. Involving business teachers is an appropriate methodology for this integration as they can help students to develop some essential skills not to waste their time designing STEM products that are not needed for anyone.” Further she asserted, “in business classes, students show interest in entrepreneurial learning, so integrating its practices into STEM is a promising idea that can better enhance their entrepreneurial attitudes. So, one or two periods with business teachers can be planned to prepare students before they start working on their STEM designs”. Moreover, the CD agreed that “business teachers can help enhance the entrepreneurial terminology among other subject teachers such as venture enterprise, business plans and market analysis that all are basics for better entrepreneurial practices.” The leaders’ discussion reflected a consensus regarding the instability of the employment process as well as the consistent increase of the workplace challenges.

- Characteristics of E-STEM Learning Environment

With respect to second theme, STEM lead teachers also elucidated that the characteristics of the learning environment needed for both STEM and entrepreneurship educations are relatively similar, which enhances the possibility of this integration. For example: the SL explained that, “experiential learning through hands-on activities is the best approach for both types of education. Moreover, the student-centred learning environment is the best to develop STEM thinking and action of entrepreneurial learning, where students work in groups and have to face the problem together in order to find an appropriate solution, while the teacher should be a facilitator who interferes if necessary.” In addition, the TL described the learning environment that better facilitates the two types of education as “the environment that has authentic opportunities of learning and allows students to learn from their mistakes and make logical decisions to solve a real-life problem.”

- Suggested E-STEM Practices

Further, participating lead teachers suggested some activities to be added to the unified STEM course curriculum. Moreover, they anticipated some changes to the STEM course pedagogy implemented in schools to support incorporating entrepreneurial learning into their STEM classes such as: “Engage teachers from business department to be responsible about entrepreneurial learning in the STEM classes.” Another suggestion was raised by the CD who believed that, “integrating activities that consider the product utility (functionality) with the STEM curriculum is a good idea to teach students to consider the value of their products, and to not to waste their time designing inappropriate products that are not needed”. Whilst the BL recommended the, “prototyping as a pre-primary sample of the proposed project. Thus, students can make surveys or presentations to know if the audience need their ideas to be applicable. School conferences are also suggested to give students a chance to create interest and convince people of their idea.” In addition to that, “incorporating entrepreneurial practices that enhance

business mindset is recommended where learning emphasizes the value and the need of the design by responding to four important economic questions such as what to produce, for whom to produce, how to produce, and when.” Furthermore, technology and ML teachers were interested in, “encouraging STEM students to have longitudinal projects with entrepreneurial endeavour that may take more than a year to achieve its purpose,” and, “ To attend summer school programs to achieve business tasks that include practical training sessions in different companies.” Moreover, “computer simulations are useful to identify the basic terminology of entrepreneurial learning and to introduce successful examples to students.” Accordingly, they agreed on “establishing a new department for entrepreneurship programs to teach and help students to understand the marketing process and to be engaged simultaneously in STEM learning process.” The other BL mentioned, “in addition to the lectures that are used to explain useful case studies, it would be beneficial to plan regular educational trips to companies, communicate with the real market and recognize its needs and challenges”. Finally, “Inviting different types of entrepreneurs to speak about their successful experiences and inspire STEM students would enhance their desire to learn more about entrepreneurship.”

- **STEM Curriculum and Students’ Entrepreneurial Competencies**

Fourthly, participants were asked about if their STEM curriculum support the development of students’ entrepreneurial competencies. Two main themes were revealed from the analysis of the academic leaders’ responses (1) current practices and (2) facilities.

- **Current STEM Practices**

Regarding the theme of ‘current practices’, the participating lead teachers, as well as the curriculum developer believed that STEM best practices in the school help equip students with the requisite entrepreneurial competencies such as creativity, planning, and reasonable and

critical thinking. Thus, the ML and SL clarified that the, “Interdisciplinary approach is the main approach used where both problem and project-based learning are implemented in the STEM classes” at their schools in the UAE, because, “their practices allow students to plan and experience success and failure and that is important for entrepreneurial learning as well. Moreover, students work and cooperate in groups to become responsible about different tasks in order to achieve the main goal, but all of this is not enough to produce new entrepreneurs; more practices should be conducted in order to facilitate this incorporation, and to make entrepreneurial learning be partially taught in STEM classes.” The SL justified her agreement to this incorporation saying, “I can tell that all STEM practices carried out in our organization such as applying technology, solving problems, engaging in logical reasoning process, students’ reflection on their learning and using teachers’ feedback for improvement, develop many of the students’ competencies that all are known as entrepreneurial competencies, which make this incorporation easy and interesting for STEM students.” Accordingly, the CD added, “STEM classes focus on creativity and innovation as well as cooperation and reasoning skills. These values are essential competencies that are required for being an entrepreneur. Moreover, engineering teachers usually have the most effective STEM practices because of their capabilities that combine science and math skills and empower students with many of the 21st century competencies; however, the long teaching experience of all other teachers support and enhance their instruction and make them more adaptable to new ideas. I have observed that the more teaching experience, the better practices applied, which affect students’ outcomes.”

- STEM Facilities

Nevertheless, many of the responses focused on the facilities utilized in the STEM implementation and their importance in supporting the STEM program and enhancing students’ competencies. SL, ML and TL teachers agreed that they have never focused particularly on entrepreneurial competencies. Their attention is usually given to develop STEM competencies

of the students such as cooperation, being persuasive and decisiveness, which are also needed for any entrepreneur. The TL said, “the organization I work for, provides a unified STEM curriculum that gives the students a wide scope about the importance of integrating the knowledge of different disciplines, as well as advanced science and engineering labs where they can work in groups to create their designs, internet access to search and collect data, a huge number of resources in the school library, and online specialized resources to learn and communicate effectively.” More details were added by the SL who mentioned, “we have an engineering department where students work collaboratively, and their STEM designs are supervised by engineering teachers who have a great experience in how to put STEM students on the right track. Besides, enrichment classes have many activities that support small business ideas, so these practices can be integrated with the STEM curriculum in order to develop more entrepreneurial competencies that we usually do not focus on STEM classes like business opportunities, product functionality and financial awareness.” The BL mentioned, “a few work placement experiences are prepared for our students to give a basic idea about the work atmosphere and expose them to practical work and real projects through some visits to the work field. This also gives them some examples of better techniques and modelling. Unfortunately, these experiences do not develop any entrepreneurial skills.”

On the other hand, the EL argued that STEM programs taught in school are not enough to generate entrepreneurs because, “STEM classes focus only on inventing not marketing. Students gain the required skills if they consistently practice because not all scientists are entrepreneurs, so STEM students can be the scientific and technological entrepreneurs of the future if some pedagogical modifications and practices are incorporated within the STEM curriculum currently used in school.” Furthermore, she believes that, “STEM classes do not emphasize any knowledge or develop the attitude of entrepreneurial learning.”

- **E-STEM Challenges**

Fifthly, participants were asked about the main challenges that eliminate the integration of entrepreneurship in STEM education. They identified many obstacles that might decelerate the process of applying the anticipated changes in the STEM course pedagogy to incorporate entrepreneurial practices into STEM classes. The BL said that the most noticeable barrier is, “the lack of information and training of teachers about entrepreneurial learning, as well as the readiness of the students to start thinking beyond school walls and thinking of their future. I can tell that our STEM students can change ideas and integrated knowledge to potential products, but simply they focus only on applying this knowledge to achieve the given task, rather than creating new valuable STEM products.” The SL explained, “some STEM teachers focus intensively on making models; however, learning outcomes can be models, projects, ideas or even social services, so it is not only projects. Adding values to the community is much more appreciated than making new designs without using them.” She believes that, “STEM teachers will face difficulty to assess entrepreneurial practices.” The TL added, “Lack of motivation is a serious issue because most of the local students are from wealthy families and they are not interested in entering new challenges and facing difficulties,” while, the SL wondered if the business teachers are ready for such incorporation. She explained, “all teachers are overwhelmed by the heavy load of the curriculum and classes, which is a clear obstacle of any further implementation.”

Furthermore, the ML reflected her doubts regarding the proposed incorporation and sadly admitted “STEM teachers in the UAE have just started to be familiar with the STEM practices. In our schools, they follow a unified STEM curriculum that helps facilitate their strategies; however, they still struggle in the implementation and not all of them master the required skills, which force us as leaders to consistently prepare PDPs to enhance their abilities and update them.” Clearly, the CD agreed adding, “it is not an easy task because such a new implementation

requires not only an academic support to prepare the STEM teachers, but also a development of the STEM curriculum that we use to effectively incorporate entrepreneurial learning and that would take a long time and a huge effort to be done successfully.” Besides, the BL explained, “companies do not accept to meet us easily, although they have social responsibility regarding youth.” More importantly, he said, “Such an incorporation requires a budget and different resources and materials. I am not sure that this will be approved by the administration.” The EL identified a common challenge between all participating leaders and described how lead teachers usually suffer from, “the competition between teachers about which discipline should take more weight in the project. Unfortunately, teachers focus on the show itself more than the outcomes of STEM work.”

Table 13: Summary of Leaders' Beliefs about Incorporating Entrepreneurial Practices into STEM Education

Interview	Summary of results
<u>Question 1</u> 1. What do you know about entrepreneurial learning?	Few leaders were familiar with this term or able to explain its purpose and characteristics because it is not included in the curriculum and their knowledge regarding it, is generally acquired from the media or personal experiences
<u>Question 2</u> 2. What is the contribution of STEM education to entrepreneurial learning?	Leaders believe that STEM education could enhance both the development and the results of the entrepreneurial learning because • Students develop the basic competencies during STEM implementation that prepare them to understand the concepts and the purpose of entrepreneurial learning when they are exposed to its elements. • It can help produce more scientific entrepreneurs.
<u>Question 3</u> 3. Can entrepreneurial learning be incorporating into STEM education? How?	• Majority of leaders believes that STEM education can be restructured to purposefully incorporate entrepreneurial practices into its curriculum as well as STEM instruction because both STEM and entrepreneurial learning are interdisciplinary that require experiential opportunities. • For successful incorporation, leaders suggested the engagement of business teachers in STEM learning.
<u>Question 4</u> 4. Does STEM program used in your organization support the development of students' entrepreneurial	• All STEM practices implemented in the schools enhance the main STEM competencies such as planning, searching, solving problems, creativity, cooperation, critical thinking, confidence, curiosity, and decisiveness, which all are known as entrepreneurial competencies as well, and engineering teachers have the best practices that enhance these skills. • The longer the teaching experience, the better STEM practices applied in the classroom to promote students' learning.

competencies? How?	• The schools have many facilities such as the engineering department, as well as science, technology and engineering labs where students can learn and develop more competencies. • Leaders admitted that not all main entrepreneurial competencies are developed in STEM class, such as seeing business opportunities, and financial awareness. The value of the product and identifying the needs of the market are not emphasized in the curriculum, and educational practices that focus on them should be emphasized more consistently.
<u>Question 5</u> 5. What are the main barriers that eliminate the integration of entrepreneurship in STEM education?	Academic leaders listed many obstacles that might prevent incorporating entrepreneurial practices into STEM education such as: - Lack of teachers' knowledge about entrepreneurial practices. - Time, resources limitation, and doubts about administration support. - Entrepreneurial practices do not fit in the STEM curriculum used, and not all students are interested in new challenges. - Lack of innovative products because many students mainly apply knowledge. - Entrepreneurial practices are difficult to assess.

Table 13 summarizes the academic leaders' views regarding incorporating entrepreneurial practices into STEM education. The main responses of the five open-ended questions are presented in the table to highlight the participants' beliefs regarding this integration.

4.1.2 Results of STEM Teacher Questionnaire

The purpose of this stage is to explain STEM teachers' perceptions regarding the effective STEM practices including current and suggested practices that enhance entrepreneurial learning in the UAE as well as the expected barriers of incorporating entrepreneurial practices into STEM

education. Thus, a cross-sectional questionnaire was distributed in six Emirates among STEM teachers who are working in different branches for the same educational organization. Accordingly, 154 eligible responses were received and analysed by using the Statistical Package for Social Sciences (SPSS, version 23). The responses of the two open-ended questions attached to the questionnaire were analysed by coding and recoding. Thus, the STEM teachers' questionnaire was then developed, distributed and the attained data was analysed to answer the following research questions:

- What are the effective practices within STEM education that enhance the incorporation of entrepreneurial practices into STEM education in the UAE?
- What are the main challenges that might prevent incorporating entrepreneurial practices into STEM education in the UAE?
- Are there any different responses of participating teachers based on their demographics regarding incorporating entrepreneurial practices into STEM education?

Both descriptive and inferential statistical analyses were applied and presented below for all items, including; One Way ANOVA test to compare mean scores among groups. Moreover, an examination of differences was applied among the main five demographic variables in the questionnaire, including: the emirate where the participating teachers work, the gender of the participant, the highest academic qualification achieved, years of teaching experience and the subject taught.

Section 1: Results of Demographics

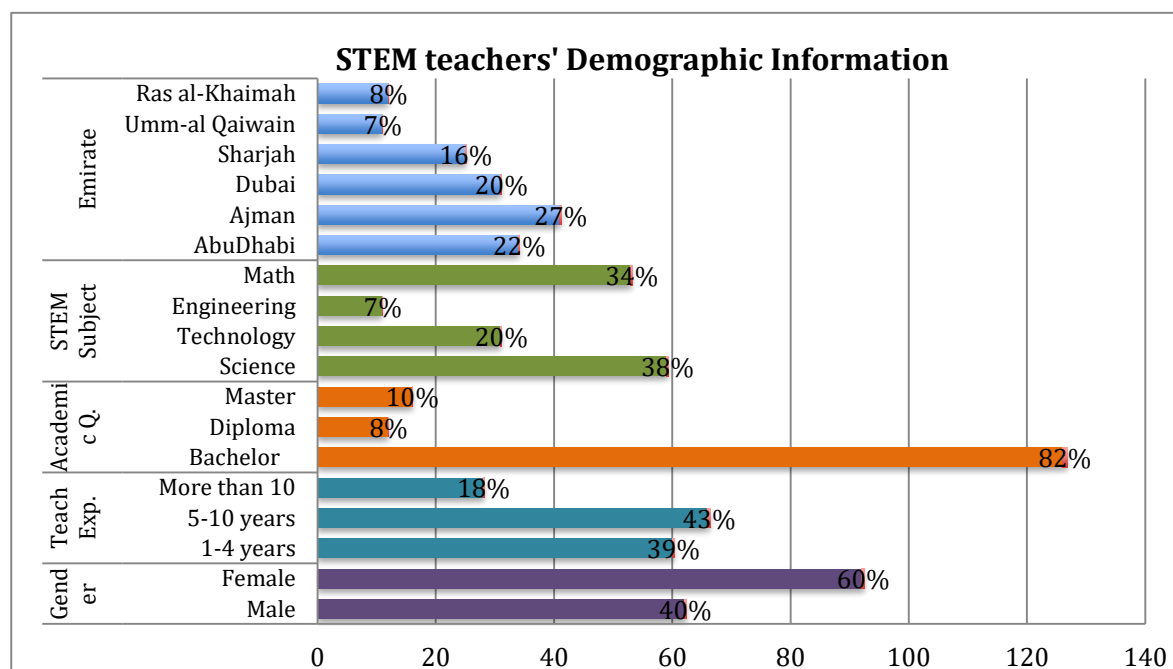


Figure 17: Demographic Information of the Participating Teachers

Figure 17 demonstrates the main demographic information of the participating STEM teachers that include gender, emirate, teaching experiences, STEM subject taught and academic qualification. Six emirates represented the geographic location of the participating teachers in the UAE where percentages of responses were (Ajman 27%), (Abu Dhabi 22%), (Dubai 20%), (Sharjah 16%), (Ras al-Khaimah 8%) and (Umm-al Qaiwain 7%) who are teaching the four main disciplines of STEM with percentages (science 38%, math 34%, technology 20% and engineering 7%). Moreover, responses from female teachers (60%) came higher than from males (40%). In respect to the teaching experience of the targeted teachers, (43%) received from teachers who have 5-10 years of experience, followed by (39%) from teachers who have 1-4 years of experience, and the least contribution (8%) came from teachers who have the longest experience in teaching, more than 10 years. Meanwhile, teachers with the least educational degree responded more significantly to the questionnaire (Bachelor 82%), whereas teachers with masters and postgraduate diplomas responded with percentage (10% and 8%) respectively.

Descriptive Statistics

The goal of descriptive statistics is “to describe, summarize, or make sense of a particular set of data” (Johnson & Christensen 2014, p. 518). Moreover, it forms the foundation of the quantitative analysis. Thus, it is used to describe the basic features and to summarize the obtained data regarding the two main variables (effective practices of STEM and the obstacles of the incorporation) by measuring the mean, standard deviation and percentage of the responses of their elements. Meanwhile, the five demographic independent variables (emirates, gender, teaching experience, academic qualification and subject taught) were considered.

Section 2: Results of Effective Practices in the STEM Classes that Enhance Entrepreneurial Learning in the light of Teachers’ Perceptions

The questionnaire asked the STEM teachers about the effective practices that enhance entrepreneurial learning in STEM classes. These educational practices were divided into two sections: current STEM practices and suggested practices that should be added to the STEM course pedagogy to facilitate entrepreneurial learning. Moreover, teachers’ current practices are separated into two main parts: problem-based learning practices and value creation practices.

- Rate of Current Practices Applied in the STEM Classes to Promote Entrepreneurial Learning

The rate of applying the current practices in the STEM classes to enhance entrepreneurial learning was obtained by endowing five options to the participating teachers. The intended options used in the questionnaire were 1= never applied, 2= rarely applied, 3=occasionally applied, 4= often applied and 5= always applied. The current practices were divided into two

main parts that are project and problem-based learning practices and Value creation practices. The results of the STEM practice that are applied currently are presented and classified in the following table.

Table 14: Descending Rate of Current Practices Applied in the STEM Classes to Enhance Entrepreneurial Learning

Current STEM Practices	Descriptive Analysis of Perceptions		
	M	SD	Percentage
PBL Practices (high rate implementation)			
Students cooperate and collaborate in a STEM team	4.78	.416	96%
Students apply technology strategically	4.76	.429	95%
Students integrate information from STEM disciplines to design new products	4.52	.502	90%
Students discuss, argue and present their projects to the classmates	4.47	.550	89%
Students plan for their inquiry	4.46	.596	89%
Students take responsibility of their own learning	4.39	.598	88%
Students reflect on their learning and modify their plans	4.32	.483	86%
Students evaluate their projects through a design rubric	4.30	.459	86%
Students use teachers' and experts' feedback to improve their products	4.28	.530	86%
Students identify the problem and pose questions	4.19	.658	84%
Students are engaged in logical reasoning to solve the problem	3.98	.610	80%
Value Creation Practices (low rate implementation)	M	SD	Percentage
Students use their STEM designs to create or add value to the society such as making service or gaining profit	2.46	.923	49%
Students study the market to know if their products are needed	1.47	.951	29%
Students calculate the costs required for their projects	1.29	.545	26%

Table 14 identifies the mean and percentages of the current practices applied in the STEM classes to enhance entrepreneurial learning. The mean scores achieved are arranged in a descending order to identify practices with the highest and lowest rates of implementation. Thus, percentages

of current practices with highest rate implementation are (96% - 89%), where students more consistently cooperate in STEM teams, apply technology, integrate information from the science, technology, engineering and math to design a new product, and discuss and present their projects and plan for their inquiries.

Practices with medium rates of implementation presented the percentage (88% - 80%), where students take responsibility for their own learning, reflect on their experiences, evaluate their project using a rubric, consider teachers' feedback to improve, identify the problem for investigation and finally, be engaged in logical reasoning processes to solve a problem. On the other hand, (49%) of teachers encourage students to use their STEM designs to add value to society or gain a profit. The lowest rate of implementation (29% - 26%) was for studying the market to understand its needs and calculate the costs of the proposed STEM project before actual implementation. Accordingly, it is apparent that teachers give more focus to the practices of PBL/PjBL approaches in their STEM classes, rather than value creation practices

- Rate of Suggested Practices that should be added to STEM Course Pedagogy to Facilitate Entrepreneurial Learning

Table 15: Descending Rate of Practices Suggested by STEM Teachers to Enhance Entrepreneurial Learning

Suggested Practices	Descriptive Analysis of Perceptions		
	M	SD	%
Establish a new department for entrepreneurship programs to incorporate entrepreneurial learning into courses where business teachers are involved	4.69	.462	94%
Attend summer school programs to achieve business tasks	4.33	.472	87%
Supplementing entrepreneurial learning with extracurricular activities	4.29	.571	86%
Hands on experience business start-up: each group of students creates a simple business to sell their products.	4.23	.613	85%
Company visits: regular trips to communicate with the real market	4.13	.773	83%

Guest speaker: invitation of entrepreneurs to speak about their successful experiences in the market.	3.97	.808	79%
Computer simulation	3.67	.667	73%

Table 15 shows the descending rate of teachers' perceptions' means and percentages of the suggested practices that should be added to their STEM course pedagogy, in order to better facilitate entrepreneurial learning. The most significant suggestion with the highest mean (4.69) came for establishing a new department of entrepreneurship programs to incorporate entrepreneurial practices into existing course curriculum with the support of business teachers. Moreover, the results have revealed that the majority of STEM teachers recommended (summer school programs, extracurricular activities, hands on experiences to start new businesses and visiting companies to allow students to communicate with the market) with (4.33, 4.29, 4.23, 4.13) respectively. On the other hand, the lowest mean (3.97 and 3.67) came for two suggested practices that are (inviting guest speaker, computer simulation) respectively.

- Rate of Effective Practices Applied in the STEM Classes to Promote Entrepreneurial Learning based on Demographic Variables (N= 154)

Table 16: Rate of Teachers' Perceptions regarding Effective Practices Applied in STEM Classes based on Demographics

Teachers' Demographics		Effective STEM Practices that enhance entrepreneurial Learning					
		Current Practices		Suggested Practices		Total Practices	STEM
		M	SD	M	SD	M	SD
Emirate							
Abu Dhabi	(n=34)	54.8	4.37	29.1	2.58	83.9	6.15
Dubai	(n=37)	53.3	4.01	29.3	2.29	82.6	5.88
Ajman	(n=35)	53.1	4.36	29.1	2.23	82.3	6.06
Sharjah	(n=25)	53.7	5.93	29.4	2.72	83.1	8.34
Ras-al-Khaimah	(n=12)	52.8	4.24	29.8	2.22	82.6	5.91

Umm-al Qaiwain	(n=11)	53.8	5.51	30.3	2.96	84.1	8.10
Gender							
Male	(n=62)	54.1	5.42	29.3	2.51	83.4	6.99
Female	(n=93)	53.4	4.33	29.3	2.41	82.8	6.23
Academic Qualification							
Master	(n=16)	64.1	1.12	33.9	1.1	98.0	1.7
Diploma	(n=12)	53	3.34	28.7	2.4	81.6	5.3
Bachelor	(n=126)	52.4	3.1	28.9	2.0	81.2	4.9
Teaching Experience							
1-4 years	(n=60)	52.1	2.83	28.9	2.01	81.0	4.20
5-10 years	(n=66)	53.2	3.8	29.1	2.09	82.3	5.18
More than 10	(n=28)	58.1	6.55	30.9	3.38	89.0	9.56
Subject taught							
Science	(n=59)	53.3	4.84	29.3	2.57	82.6	7.0
Technology	(n=31)	53.2	4.5	29	2.16	82.1	6.03
Engineering	(n=11)	58.6	3.11	32.3	1.56	90.8	3.52
Mathematics	(n=53)	53.4	4.23	29	2.24	82.3	5.8

Table 16 demonstrates the descriptive analysis of the collected data on the rate of teachers' perceptions regarding effective practices that are applied in the STEM classes to promote entrepreneurial learning in respect to the five variables of the demographic information obtained.

With respect to the participants' emirate, the mean scores of the total effective practices ranged between the lowest (M= 82.3) from Ajman teachers to the highest (M= 84.1) from Umm-al Qaiwain teachers, including: current practices between (M= 52.8) in Ras al-Khaimah and (M= 54.8) in Abu Dhabi, and suggested practices from Ajman and Abu Dhabi (M= 29.1) to Umm-al Qaiwain (M= 30.3).

In regard to the gender of participating teachers, although mean scores are close, male teachers apply more current practices (M= 54.1) in STEM classes to facilitate entrepreneurial learning than females (M= 53.4); however, the rate of their suggested practices of the proposed

incorporation is equal (29.3). In total, the rate of male's effective practices ($M= 83.4$) is slightly more than female teachers ($M= 82.8$).

Moreover, regarding the academic qualifications of the participating STEM teachers, it was concluded that STEM teachers possessing a master's degree currently apply more effective practices ($M= 64.1$) than both diploma teachers ($M= 53$) and bachelor teachers ($M= 52.4$). Perceptions regarding suggested practices are (master, $M= 33.9$), (diploma, $M= 28.7$) and (bachelor, $M= 28.9$). The most positive perceptions regarding the total effective practices came from the higher educational degree (master, $M= 98.0$) followed by diploma ($M= 81.6$) and bachelor ($M= 81.2$).

According to the teaching experience, the highest mean score of current STEM practices was for the longest experience where ($M= 58.1$) for teachers with more than 10 years as compared to (5-10 years, $M= 53.2$) and (1-4 years, $M= 52.1$). Suggested practices arranged in the same order of experience (30.9, 29.1 and 28.9) respectively. Consequently, the most positive perceptions regarding the total effective practices were for instructors who have taught for more than 10 years ($M= 89.0$).

Finally, in respect to the subject taught, engineering teachers currently apply more practices ($M= 58.6$) and they suggested more practices for implementation ($M= 32.3$), while the mean scores of current STEM practices were closely ranged between 53.2 and 53.4 for technology, science and math teachers who suggested practices with approximately equal means ($M= 29$). As a result, engineering teachers have the most significant applications of effective practices ($M=90.0$) in comparison to other subject teachers that achieved means ranged between 82.1 and 82.6.

Section 3: Results of Challenges

- **Rate of Challenges that can prevent incorporating entrepreneurial practices in STEM education**

Table 17: Descending Rate of Obstacles of Incorporating Entrepreneurial Practices into STEM Education

Obstacles of incorporation	Descriptive Analysis of perceptions	
	M	SD
Challenges		
Lack of teachers' knowledge about entrepreneurial practices	4.56	.510
Entrepreneurial practices are difficult to assess	4.44	.547
Time limitations	4.42	.546
Lack of administrative support	3.29	.907
Lack of materials, resources and funding	3.22	1.005
Lack of innovative products: students' projects are regular and not required in the market	3.18	.939
Entrepreneurial practices do not meet my students' interests	2.69	.917
Entrepreneurial practices do not fit in the STEM curriculum used	2.57	1.114

Table 17 shows the descending order of the mean responses regarding the obstacles of incorporating entrepreneurial practices into STEM education. Results revealed that the lack of teachers' knowledge about entrepreneurial practices, the difficulty of assessing these practices and the limited time provided for implementation are the most significant challenges that face teachers with means (4.56, 4.44 and 4.42) respectively. In second place, another three obstacles are shown (lack of administrative support, lack of materials and lack of innovative products) with means (3.29, 3.22 and 3.18) respectively. Finally, the least significant challenges that face teachers are entrepreneurial practices do (not meet students' interest and not fit in the STEM curriculum used) with means (2.69 and 2.57) respectively. Moreover, two values of standard deviations are much higher than the mean scores, which indicate that the data set of these two

obstacles (lack of materials, entrepreneurial practices do not fit the STEM curriculum) is not normally distributed and their range of distribution is large.

- **Rate of Challenges that can prevent incorporating entrepreneurial practices in STEM education based on Demographic Variables (N= 154)**

Table 18: Rate of STEM Teachers' Perceptions regarding Obstacles of Incorporation based on Demographics

Teachers' Demographics		Obstacles of incorporating entrepreneurial	
		M	SD
Emirate			
Abu Dhabi	(n=34)	28.38	4.45
Dubai	(n=37)	29.00	4.04
Ajman	(n=35)	27.91	4.50
Sharjah	(n=25)	28.36	3.03
Ras al-	(n=12)	28.42	2.78
Umm-al	(n=11)	27.82	3.57
Gender			
Male	(n=62)	28.2	4.13
Female	(n=93)	28.5	3.84
Academic Qualification			
Master	(n=16)	31.4	3.07
Diploma	(n=12)	26.8	4.73
Bachelor	(n=126)	28.2	3.81
Teaching Experience			
1-4 years	(n=60)	28.2	3.66
5-10 years	(n=66)	28.0	4.13
More than 10	(n=28)	29.7	4.02
Subject taught			
Science	(n=59)	27.9	3.82
Technology	(n=31)	28.2	3.54
Engineering	(n=11)	33	1.84
Mathematics	(n=53)	28.1	4.1

Table 18 demonstrates the descriptive analysis of the collected data on the rate of teachers' perceptions regarding obstacles of incorporating entrepreneurial practices into STEM, with respect to the five variables of the demographic information obtained.

With regard to participants' emirate, the highest mean score of obstacles came from participating STEM teachers in Dubai ($M= 29$, $SD= 4.04$); however, the mean scores of teachers' responses were relatively equal from Abu Dhabi, Sharjah, Ras al-Khaimah, Ajman and Umm-al Qaiwain ($M=28$).

With respect to the gender, the difference between mean scores of males and females is low; however, female STEM teachers perceived more obstacles in incorporating entrepreneurial practices in STEM education ($M= 28.5$, $SD= 3.84$) than male teachers ($M= 28.2$, $SD= 4.13$).

According to academic qualification of participants, the highest mean scores of challenges came from teachers with a master's degree ($M= 31.4$, $SD= 3.07$), followed by teachers with a bachelor's, and then those with a diploma, who responded less positively to barriers of incorporation with scores ($M= 28.2$, $SD= 3.81$) and ($M= 26.8$, $SD= 4.73$) respectively.

Furthermore, the highest mean scores of obstacles came from teachers who have more than 10 years teaching experience ($M= 29.7$, $SD= 4.02$), while, the mean scores came fairly equally from teachers with less working experience (1-4 years; $M= 28.2$, $SD= 3.66$) and (5-10 years; $M= 28$, $SD= 4.13$).

Finally, with respect to the subject taught, the most perceived challenges of incorporating entrepreneurial practices into STEM education came from engineering teachers ($M= 33$, $SD= 1.84$), followed by technology and mathematics teachers with mean scores ($M= 28.2$, $SD= 3.54$) and ($M= 28.1$, $SD= 4.1$) respectively. The least perceived obstacles came from science teachers ($M= 27.9$, $SD= 3.82$).

Inferential Statistics

In order to examine the relationship between variables within the study sample, inferential statistics are needed. The goal of inferential statistics is, “to go beyond the immediate data and to infer the characteristics of populations based on samples” (Johnson & Christensen 2014, p. 518). The mean scores of the two dependent variables are compared to the teachers’ demographics as independent variables. These demographics of STEM teachers (independent variables) are Emirate, gender, academic qualifications, teaching experience and subject taught. The two dependent variables are effectiveness practices of STEM classes that enhance entrepreneurial learning, and obstacles of incorporating entrepreneurial practices into STEM education. Moreover, the null hypothesis is that there are no significant differences of the mean scores of the two dependent variables based on any of the teachers’ demographics.

Group difference by Emirate

Table 19: ANOVA Table for the Group Difference by Emirate of Participants

One Way ANOVA/Emirate						
Variable	Difference	Sum of Squares	DF	Mean Square	F	Sig.
Effective Practices	Between Groups	68.58	5	13.72	.314	.904
	Within Groups	6457.43	148	43.63		
	Total	6526.00	153			
Obstacles of E-STEM	Between Groups	25.31	5	5.06	.318	.902
	Within Groups	2359.09	148	15.94		
	Total	2384.40	153			

Table 19 introduces the results obtained from the ANOVA test showing the mean scores of six groups of participants’ Emirates; Abu Dhabi, Dubai, Ajman, Sharjah, Ras al-Khaimah and Umm-al Qaiwain. This analysis indicated that the differences between groups’ perceptions

regarding both the effective STEM practices that enhance entrepreneurial learning ($F = .314$, $p > 0.05$) as well as the obstacles of the proposed incorporation are not statistically significant among the six groups and ($F = .318$, $p = .902$).

Group difference by Gender

Although the independent variable of gender includes two groups, males and females, the t-test was not selected to examine the group difference because it is not robust to unequal sample sizes (Field 2018). Accordingly, One Way ANOVA was also used to examine the differences between groups.

Table 20: ANOVA Table for the Group Difference by Gender of Participants

One Way ANOVA/ Gender						
Variable	Difference	Sum of Squares	DF	Mean Square	F	Sig.
Effective Practices	Between Groups	14.28	1	14.28	.333	.565
	Within Groups	6511.72	152	42.84		
	Total	6526.00	153			
Obstacles of E-STEM	Between Groups	3.12	1	3.12	.199	.656
	Within Groups	2381.27	152	15.67		
	Total	2384.40	153			

Table 20 introduces the results obtained from the ANOVA test showing the mean scores of participants' gender. With respect to the gender of the participating teachers, the results have shown that there is no significant difference at $\alpha=0.05$ between perceptions of males and females' teachers regarding effective practices ($F = .333$, $p = .565$) as well as obstacles of incorporation ($F = .199$, $p = .656$).

Group difference by Academic Qualification

The independent variable of academic qualifications included three groups: Master's degree, Postgraduate diploma and bachelor's degree. One-Way analysis of variance (ANOVA) was conducted (Field 2018) to evaluate the null hypothesis that the mean (average value of the dependent variables (effective practices and obstacles) is the same for all groups. Thus, when there is no difference in mean scores, it indicates that there is no difference in teachers' perceptions (N= 154) based on their academic qualification.

- Normality Test

Prior to conducting the ANOVA, the assumption of normality was evaluated (appendix 10) where the results of Shapiro-Wilk assume that scores of effective practices obtained from masters ($p=.429$) and diploma qualified teachers ($p= .843$) are normally distributed (Shapiro & Wilk 1965). Similarly, normal distribution of the scores of obstacles of incorporation obtained from teachers with a master's degree ($p= .085$) and diploma ($p= .263$) which all are > 0.05 . Contrary to the scores from teachers with a bachelor's degree have no normal distribution for both variables ($p= .000$), which does not reflect tangibility of assumptions. Thus, when the scores are not normally distributed, "transforming data"(Field 2018, p.268) through SPSS to provide a ranked transformed data is used to address this problem (Nordstokke et al. 2011), and a new nonparametric Levene's test verified the equality of variances in the samples where homogeneity of variances $p > 0.05$ (Nordstokke & Zumbo, 2010).

- Levene's Test (homogeneity of variances)

The new nonparametric Levene's test is defined as "a parametric analysis of variance conducted on rank transformed data" (Nordstokke et al. 2011, p. 3). Levene's test is often conducted before a comparison of means to verify the assumption that mean scores of variables have equal variances ($p> .05$) (Levene 1960). Thus, the assumption of homogeneity of variances was tested

for effective practices ($F= 18,14$, $p= .000$). The significant result of the p value < 0.05 rejects the assumption of equal variances (Field 2018) for the variable of effective practices, while equal variances are assumed in case of the homogeneity of the variable of obstacles ($F= 2,771$, $p= 0.66$). This means that scores of effective practices have equal variances, while scores of obstacles have unequal variances based on the academic qualification of teachers.

- ANOVA Test

One-Way ANOVA test was conducted to identify whether or not a difference exists somewhere between the groups. The following table introduces the results of the ANOVA analysis for the two proposed variables in terms of the academic qualifications of participants.

Table 21: ANOVA Table for the Group Difference by Academic Qualification of Participants

One Way ANOVA/ Academic Qualification							
Variable	Difference	Sum of Squares	DF	Mean Square	F	Sig.	η^2
Effective Practices	Between Groups	13478.352	2	6739.18	18.545	.000	.02
	Within Groups	54872.142	151	363.392			
	Total	68350.493	153				
Obstacles of E-STEM	Between Groups	1345.531	2	672.765	1.403	.249	
	Within Groups	72429.151	151	479.663			
	Total	73774.682	153				

Table 21 introduces the results obtained from the ANOVA test showing the mean scores of participants' academic qualifications. The ANOVA was significant only for the variable of effective practices (effective practices ($F= 18.545$, $p= .000$). Thus, there is an evidence to reject the null hypothesis and conclude a significant difference with small effect size ($\eta^2= .02$) between the mean scores of effective practices based on teachers' academic qualifications. On the other

hand, the insignificant p value > 0.05 of the variable of ‘obstacles’ ($F= 1.403$, $p= .249$) concludes that there is no difference between the mean scores of obstacles based on the academic qualifications of participants. For data with unequal variances, the Welch-Satterthwaite correction as a robust test of equality of means is recommended (Field 2018). Thus, p value of the Welch test is significant ($p= .000$) to confirm the differences between mean scores of effective practices among the groups based on teachers’ academic qualifications. Accordingly, the Post hoc test was implemented only for the effective practices to identify which groups are significantly different.

- Post Hoc Test

To evaluate the nature of the differences of the effective practices between the three means further, a post hoc test is necessary when the null hypothesis of ANOVA is rejected and there are three groups to compare their means. Thus, the statistically significant ANOVA was followed-up with “Games-Howell” (Field 2018, p.551) post hoc test for the data of unequal sample size of groups and unequal variances as well.

Table 22: Post Hoc Comparison with the Use of Games-Howell Test

Multiple Comparisons							
Games-Howell							
Dependent Variable	(I)Academic Qualification	(J)Academic Qualification	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Effective Practices	Master	Diploma	-36.44835*	5.56961	.000	-51.4374	-21.4593
		Bachelor	-29.43013*	1.89746	.000	-33.9250	-24.9352
	Diploma	Master	36.44835*	5.56961	.000	21.4593	51.4374
		Bachelor	7.01822	5.81919	.470	-8.2875	22.3240
	Bachelor	Master	29.43013*	1.89746	.000	24.9352	33.9250
		Diploma	36.44835*	5.56961	.000	21.4593	51.4374

		Diploma	-7.01822	5.81919	.470	-22.3240	8.2875
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*. The mean difference is significant at the 0.05 level.

Table 22 shows the Post Hoc comparison with the use of Games-Howell test. The results revealed significant pairwise differences ($p < .05$) between the mean scores of effective practices that enhance entrepreneurial learning ($p = .000$) that come from STEM teachers with a master degree and other teachers who have either a diploma or bachelor's degrees. On the contrary, the mean scores are not significantly different between teachers who have a Diploma and those whom have bachelor's degrees ($p > .05$). These results indicated that mean scores of teachers of high academic qualification (master's degree) were more significant than others.

Group difference by Teaching Experience

Regarding the group difference in terms of the teaching experiences of participants, there are three different groups as well; (1-4) years' experience, (5-10) years' experience and more than 10 years teaching experience. In this regard, the ANOVA test is used as a statistical method to test the differences among more than two means.

The normality test (Appendix 10) was conducted and did not find tenable for all groups where the p value was significant at the < 0.05 alpha level for all the three groups of the two dependent variables. This indicates that the scores of both effective practices as well as obstacles are not normally distributed based on the teaching experiences of the participating teachers. Therefore, data was transformed in SPSS and a non-parametric Levene's test was used (Nordstokke & Zumbo, 2010) to assess the equality of variances for both of the dependent variables. Furthermore, the Homogeneity of variances (Appendix 10) was tested and confirmed equal variances ($p > .05$) for all groups (effective practices $p = 0.904$) and (obstacles $p = .804$). The following table introduces the results of the ANOVA analysis for the same two variables in terms of the teaching experiences of participants.

Table 23: ANOVA Table for the Group Difference by Teaching Experience of Participants

One Way ANOVA/ Teaching Experience							
Variable	Difference	Sum of Squares	DF	Mean Square	F	Sig.	η^2
Effective Practices	Between Groups	5739.85	2	2869.92	6.327	.002	.08
	Within Groups	68495.94	151	453.62			
	Total	74235.77	153				
Obstacles	Between Groups	797.46	2	398.73	.805	.449	
	Within Groups	74800.88	151	495.37			
	Total	75598.34	153				

Table 23 of ANOVA reveals the mean scores of participants' teaching experiences for both the dependent variables for all three groups. The mean scores of the effective practices were significant and reflected differences between groups where ($F= 6.33$, $p= .002$) with medium effect size ($\eta^2= .08$). On the other hand, the value of ($p= .449$) for the variable obstacles that is more than .005, which supports the null hypothesis and concludes that there is no difference between the mean scores of obstacles based on the teaching experiences of participants. Thus, there is a significant difference between groups in relation to effective practices and there is no significant difference between groups in relation to obstacles. Accordingly, the post hoc test was implemented only for effective practices to identify which groups are significantly different based on the teaching experience of participants.

- **Post Hoc Test**

Table 24: Post Hoc Comparison with the Use of Hochberg Test

Multiple Comparisons							
Hochberg							
Dependent Variable	(I)Teaching Experience	(J)Teaching Experience	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Effective Practices	1-4 years	5-10 years	-6.148	3.799	.288	-15.32	3.02
		More than 10	-17.316*	4.875	.002	-29.08	-5.55
	5-10 years	1-4 years	6.148	3.799	.288	-3.02	15.32
		More than 10	-11.168	4.803	.063	-22.76	.43
	More than 10	1-4 years	17.316*	4.875	.002	5.55	29.08
		5-10 years	11.168	4.803	.063	-.43	22.76

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

Table 24 shows the Post Hoc comparison with the use of Hochberg test. The data has unequal sample size and equal variances; the Hochberg's GT2 pairwise test was conducted to detect the groups with significant mean scores (Field 2018). The results of Hochberg Post Hoc test in the previous table indicates that the mean scores of effective practices of teachers who have more than 10 years experiences are significantly different than those of only (1-4)-years' experience where $p= 0.02$; however, there is no statistically significant difference of the mean scores obtained from teachers with (1-4 years) and (5-10 years). This means that mean scores of teachers with long teaching experience (more than 10 years) are more statistically significant than other teachers with a shorter teaching experience.

Group difference by Subject Taught

The independent variable, 'subject taught' contains four groups that are science, technology, engineering and mathematics. Accordingly, One-Way ANOVA is the appropriate test to evaluate the null hypothesis that there is no difference between the mean scores among the four groups based on the subject that participants teach.

Thus, similar procedures to the previous two dependent variables were conducted. First, the normality test was carried out where the results of Shapiro-Wilk's test ($p > 0.05$) (Razali & Wah 2011) have shown that the sample data was not approximately normally distributed for both variables because of the value of $p < 0.05$ (appendix 10). Therefore, when the distribution of the population is skewed, a new non-parametric version of Levene's test is used to verify the equality of variances in the samples of effective practices where (homogeneity of variances $p > 0.05$) (Nordstokke et al. 2011). The value of p was significant for both variables (effective practices $p = .000$) and (obstacles, $p = .031$). Thus, the null hypothesis of equal variances is rejected, and these unequal variances conclude that there is a difference between variances among population. In this regard, the Welch test (appendix 10) is recommended to evaluate if there is a difference between means because it is more powerful and reliable (Field 2018) when the samples have unequal sample size and unequal variances. The Welch test provided a significant $p < .05$ for both variables and confirmed the alternative assumption of unequal variances.

Table 25: ANOVA Table for the Group Difference by Subject Taught of Participants

One Way ANOVA/ Subject Taught							
Variable	Difference	Sum of Squares	DF	Mean Square	F	Sig.	η^2
Effective Practices	Between Groups	11752.584	3	3917.528	8.648	.000	.15
	Within Groups	67947.859	150	452.986			
	Total	79700.443	153				
Obstacles of ESTEM	Between Groups	5562.017	3	1854.006	4.095	.008	.08
	Within Groups	67914.199	150	452.761			
	Total	73476.216	153				

Table 25 represents the ANOVA result where it has shown a statistically significant effect on the independent variable (subject taught) among the means of both dependent variables (effective practices $F = 8.65$, $p = .000$, $\eta^2 = .15$) and (obstacles $F = 4.095$, $p = .008$, $\eta^2 = .08$). Accordingly, the null hypothesis of no differences between the means of groups was rejected and the subject taught accounted for (15% and 8%) of the variance in (effective practices and obstacles) respectively. Thus, the results indicated that there is a significant statistical difference between groups in relation to the subject they teach to students. Accordingly, the Post Hoc test was conducted for both the dependent variables.

- **Post Hoc Test**

Post hoc comparisons to evaluate pairwise differences among the means of the four groups were conducted with the use of Games-Howell test as the most appropriate test for the data with unequal variances (Field 2018) and unequal sample size as well.

Table 26: Post Hoc Comparison with the Use of Games-Howell Test

Multiple Comparisons							
Games-Howell							
Dependent Variable	(I)Subject Taught	(J)Subject Taught	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Effective Practices	Science	Technology	2.119	4.833	.972	-10.64	14.88
		Engineering	35.127*	3.139	.000	26.86	43.39
		Math	5.835	4.183	.505	-5.08	16.75
	Technology	Science	-2.119	4.833	.972	-14.88	10.64
		Engineering	33.007*	4.084	.000	22.00	44.01
		Math	3.715	4.932	.875	-9.29	16.72
	Engineering	Science	-35.127*	3.139	.000	-43.39	-26.86
		Technology	-33.007*	4.084	.000	-44.01	-22.00
		Math	-29.292*	3.290	.000	-37.98	-20.61
	Math	Science	-5.835	4.183	.505	-16.75	5.08
		Technology	-3.715	4.932	.875	-16.72	9.29
		Engineering	29.292*	3.290	.000	20.61	37.98
Obstacles of E-STEM	Science	Technology	1.925	4.693	.977	-10.44	14.29
		Engineering	19.306*	4.777	.002	6.13	32.48
		Math	-5.042	4.178	.624	-15.94	5.86
	Technology	Science	-1.925	4.693	.977	-14.29	10.44
		Engineering	17.381*	5.270	.013	3.03	31.74
		Math	-6.967	4.734	.460	-19.44	5.51
	Engineering	Science	-19.306*	4.777	.002	-32.48	-6.13
		Technology	-17.381*	5.270	.013	-31.74	-3.03
		Math	-24.348*	4.817	.000	-37.61	-11.08
	Math	Science	5.042	4.178	.624	-5.86	15.94
		Technology	6.967	4.734	.460	-5.51	19.44

		Engineering	24.348*	4.817	.000	11.08	37.61
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*. The mean difference is significant at the 0.05 level.

Table 26 of the post hoc test revealed that the differences between the mean scores of effective practices ($p = .000$) as well as obstacles ($p < .05$) attained by engineering teachers are statistically significant in comparison to all the other three-subject teachers.

Section 4: Qualitative Questions

To maximize the inter-coder reliability used to analyse the data, main codes were developed by the researcher of the study and then compared to the codes determined by an independent coder who identified the main themes of the first question (Hruschka et al. 2004). Thus, the researcher identified the following themes (1) authentic learning and (2) competency-based practice. Similarly, the independent coder, after looking at the given responses to the first open-ended question, identified the following themes for teachers' perceptions (1) real-life learning experience and (2) outcomes as modern skills. At the end, one set of themes was approved to analyse the data as follow:

- **STEM practices that can enhance students' entrepreneurial skills**

The first open-ended question asked teachers of STEM disciplines about the STEM practices that can enhance students' entrepreneurial skills. Two main themes were developed to introduce STEM teachers' perceptions regarding their best practices that enhance students' entrepreneurial skills: (1) authentic learning practices and (2) competency-based practice.

- **Authentic Learning**

Regarding the first theme ‘authentic learning,’ a chemistry teacher explained that, “project and problem-based learning are the most important strategies that allow students to investigate real life problems through authentic learning environments that provide students with multiple opportunities to promote entrepreneurial skills such as creativity, problem solving. Also, the school emphasizes utilizing these strategies because the MOE recommended them to support the National Agenda of the UAE”. In addition to what physics teachers agreed on “[they] rely on Design-based problem-solving instruction as the best practice to emphasize the meaningful learning outcomes that can be achieved in STEM classes. “Although STEM teachers do not mean to focus on entrepreneurial skills, STEM students acquire many 21st century skills that are essential for any entrepreneur such as curiosity, planning for inquiries, persuasiveness and being more independent and confident as well.” Chipping into the conversation, the engineering teacher noted, “applying a unified STEM curriculum makes all teachers work in harmony and cooperate under the umbrella of authentic learning experiences.”

- **Competency-based Practice**

With respect to the theme of competency-based practice, a technology teacher confirmed, “in spite of the confidence that STEM students gain when they apply technology and take responsibility of their own learning, they do not practice taking financial risks at all. All STEM practices are secured and controlled under the school supervision. Besides, entrepreneurial competencies such as marketing and being initiative are not emphasized in STEM classes”. Furthermore, math teachers who proudly defined their practices in the STEM classes as “competency-based learning practices” gave more details about their instruction saying, “teaching that target competencies focuses mainly on the consistent development of learning skills as well as the content knowledge. Accordingly, PjBL and PBL are often implemented to

allow students to plan, collect data to solve a problem, present their outcomes, reflect on their learning experiences and take teachers' feedback to modify their future inquiries". An engineering teacher defined his best practice as, "the strategy that allow students to translate all the possible integrated knowledge they have learned from different subjects into a design that is useful to solve a real-life problem through applying scientific knowledge and constructing new meanings".

- **Suggested Methods of E-STEM**

Second open-ended question asked teachers to suggest some ways to enhance incorporating entrepreneurial practices into STEM education. STEM teachers' responses revolved around two main themes which are (1) integrating business and (2) experiential learning activities.

- **Integrating Business**

It was clearly observed during the discussion that the majority of the participating teachers suggested involving business teachers in the STEM learning practices, as they are more aware of the entrepreneurial learning than STEM teachers. Thus, the biology teacher indicated, "integrating information from a business subject is the most helpful way to prepare STEM students for entrepreneurship in general". Accordingly, a math teacher explained, "curriculum developers in the school should adopt this new integration to guide all STEM teachers during the implementation stage", and she added, "Not all STEM teachers are familiar with the appropriate entrepreneurial practices that are suitable for high school students, and that will definitely affect their instruction and might increase students' misconception". Moreover, an engineering teacher explained, "high school students have limited opportunities to communicate with the workplace". Thus, "consistent communication between the school and the related companies in the field is essential for STEM students to connect more closely with

the labour market, to understand the value of their STEM designs and to be motivated to introduce new ideas that facilitate the needs of their society”.

- Experiential Learning Activities

Technology teacher believed, “applying business tasks through experiential learning during summer courses is a very good idea that exposes STEM students to the knowledge as well as the entrepreneurial challenges in order to acquire the identity of people who are able to take risks and address financial problems practically”. A chemistry teacher argued, “a combination of activities that can be applied in and out of the school can influence the entrepreneurial identity of the students such as computer simulation, extracurricular activities that provide students with real business opportunities to experience the success and failure”. In this regard, a math teacher gave her opinion saying, “in order to promote the entrepreneurial identity of STEM students, a new system should be generated, and teachers should receive an effective professional development programs to introduce new educational models that achieved this goal”. In a nutshell, a science teacher summarized his idea saying, “it would be interesting if the school can establish a new department of STEM learning with business activities where teachers are able to implement a new unified curriculum that focuses more intensively on practices that enhance students’ entrepreneurial identity”.

4.1.3 Results of E-STEM Implementation

The implementation of integrated E-STEM provides students with authentic learning opportunities to integrate knowledge from the five main disciplines. Thus, the scientific inquiry, mathematical thinking, technological tools, engineering design, and entrepreneurial act were all clearly recognized in each project to enhance the visibility of the learning path of E-STEM. Students identified their projects and how they are connected to the market to satisfy

its needs. The participating high school students of grades 10 and 11 in the UAE conducted vending machine, smart bus, blind currency, and virtual reality through E-STEM incorporation. The following table illustrates the main pulleys of these examples of E-STEM projects.

Table 27: Outcomes of Integrated E-STEM knowledge - based Designs

Integrated E-STEM Knowledge						
E-STEM	Experiential learning through project/problem-based E-STEM learning practices					Entrepreneurial endeavour
	Integrated E-STEM disciplines					
STEM design	Science	Math	Technology	Engineering	Entrepreneurship	Connection to the market
Vending Machine	Materials used: wood, foam, cartoon, plastic	Measurements and data calculation	Search to select and understand the usability of materials	Designing the vending machine and test its functionality	Identifying the value, calculating the cost & making a business plan	Project used in the school. Used uniforms, stationery & books were sold. Profit was achieved
Smart Bus	Simple electric circuit, transformation of energy, chips and sensors of temperature and motion	Determining the measurements and the distances needed for the project feasibility	Usability and making an application to follow the chips found in the school bus	Designing the project by connecting the chip to the mentioned sensors	Value identified. Cost calculated. Business plan designed. Target customers selected	Project was displayed in the Think Science Day. Presented to parents and teachers. The application was sold to customers from parents. Profit was achieved.
Blind Currency	Understanding the concept of eye, colours and visually impaired person	Calculation and value of currencies Low vision population statistic in UAE	Usability, research, presentation and data collection	Designing the project	Value identified, Cost calculated, Business plan designed, and project presented to audience,	Prototype was presented in Taqqadam program. Market feedback was considered. Possible modifications were studied.

Virtual reality	Eye lens, materials	Measurements , calculations of distances	making 3DDimensional lessons through making application for simulation environment	Designing the project in the shape of 3D glass	Value identified, Cost calculated, Business plan designed, and project presented to audience	Prototype was presented in Taqqadam program. Market feedback was considered. Possible modifications were studied
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Table 27 summarizes how knowledge from E-STEM disciplines was integrated effectively through an experiential learning approach that supports problem-based E-STEM practices. The data presented in the table clarifies how the gap between STEM designs and the market is considered. The main learning objective was to recognize that the process of engineering design usually conducted through integrating knowledge from science, math technology and engineering to solve authentic problems should be introduced to the market and add actual value to both the designers and to the target customers as well. When students create a design, they should plan to expand their activities to reach more people and must not accept their work and effort being missed, lost or left in the classroom with no use. Thus, the value of integrating business knowledge and incorporating entrepreneurial practices into STEM education is considered.

Students were asked to identify the value of their E-STEM project and its uses and benefits to the target audience. Scientific knowledge is applied to identify the relationship between scientific concepts and the most appropriate materials required to design the project. Furthermore, measurements, distances or statistics are usually needed through applying mathematical calculations to solve the problems, while, technology is essential for students to search, select and understand the usability of materials and/ or to use applications that facilitate their tasks. Students were asked to test the functionality of their STEM designs and to enhance the quality of their products consistently. Acting entrepreneurially encouraged students to calculate the costs, prepare their business plans and present their engineering designs to the

available market. Students were able to connect to the market and to introduce the value of their projects to the audience through different events such as school activities, Think Science Day, and the Taqqadam program where they were able to compete and to receive feedback to modify and improve their project.

E-STEM Projects

STEM Students of grade 10 and grade 11 were recruited to implement E-STEM model in two academic terms consistently. The fifty-eight participants were divided into ten groups where each group consists of five or six students who were working collaboratively to create value for the community. The following results represent the E-STEM projects achieved by the participating students in the light of E-STEM features mentioned by the participating E-STEM leaders and teachers. Each group of students was able to integrate knowledge from the five main disciplines that form E-STEM. Moreover, E-STEM teachers were guided to integrate pedagogical practices from STEM education and EE to provide students with successful entrepreneurial experiences within STEM context.

E-STEM Project 1

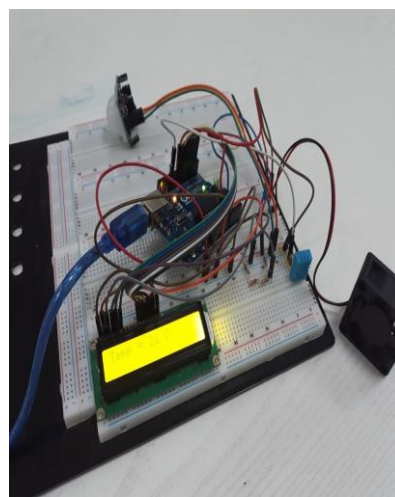
A group of E-STEM students designed a school vending machine to be used in the school community in order to sell different essential educational items, such as uniforms, books, stationery, and other educational products. This project can save time and money because it helps students avoid queues and buy their necessary goods through the vending machine. This group of E-STEM Students were able to design a small prototype of



the vending machine where only stationery items were available to be sold in the school and they were able to gain a profit.

E-STEM Project 2

This project is called ‘smart bus’. It aims to solve an important problem, which is leaving kids in buses by mistake that may cause death. E-STEM students have used a chip that is developed to have a temperature sensor, motion sensor and a SIM card. Thus, the motion sensor can detect the movement of the child forgotten in the bus, while the SIM card sends a message to the driver and bus assistant. Moreover, the temperature sensor is programmed to turn on a fan to reduce the high temperature in the bus. The students introduced their project in the Think Science Day and worked on their business plan. More interestingly, they were able to design a sticker containing a sensor connected with an application for people to follow their kids when they are in the school bus or other places outside home. This group of students achieved a profit by selling their stickers to parents of young students.



E-STEM Project 3

This project is called blind currency. It aims to help blind people to identify the amount of money they have or receive from others, in case of any fraudulent transactions. The students introduced their prototype in a new school program called Taqaddam, which is a partnership project between the



British Council and HSBC bank. This program helps students reach their potential and develop their life skills to serve the community.

E-STEM Project 4

This project is called ‘Virtual Reality Lessons’. It aims to use technology to create a simulated-educational environment where students are placed inside the experience of any lesson taught at the school. Instead of watching the blackboards or smart screens, the VR gives more life to the learning experience through interacting with the three-dimensional (3D) world. Students were able to reduce the cost of this product in comparison to the equivalent products found in the market. Moreover, the prototype and the business plan were introduced in the Taqaddam program and it was nominated to be one of the top ideas that can be adopted in the educational field.



4.2 Results of the Confirmatory Stage

The E-STEM model was tested through conducting a convergent parallel design that includes two main concurrent paradigms (third and fourth paradigms) through implementing the E-STEM model to investigate the impact of its practices on enhancing students’ entrepreneurial competencies. Thus, a focus group interview was conducted with three of the STEM teachers (science, technology and business) who volunteered to implement E-STEM model in their classes to explore STEM teachers’ perceptions about the impact of E-STEM model. Moreover, another two STEM teachers (engineering and math) responded to the interview questions by email. Furthermore, a questionnaire was given to E-STEM students twice, before and after the

E-STEM implementation to examine the effect of E-STEM practices on the entrepreneurial competencies of the students.

4.2.1 Results of E-STEM Teachers Interview

The purpose of this interview is to explore the perceptions of the recruited teachers regarding the impact of E-STEM Model based on their experience of applying the proposed model. Thus, the interview was conducted, and the qualitative data was analysed to answer the following study question:

- What beliefs do E-STEM teachers have regarding the impact of implementing E-STEM model on students' learning outcomes?

Qualitative Data Analysis

Five open-ended questions were asked in the interviews. The same three fundamental stages of Miles & Huberman (1994) were used to analyse the given data, data reduction, data display and drawing a conclusion. More details about the identified themes are given in the following section:

- **E-STEM Impact on Students' Learning Outcomes**

Firstly, with respect to the impact of E-STEM model on students' outcomes, responses of teachers emphasized both personal and community impacts in three main premises (1) intrinsic motivation, (2) entrepreneurial competencies and (2) inspiration.

- **Students' Intrinsic Motivation**

MT said, "I found a great effect of E-STEM model on our students' learning; it started when we introduced the idea of the model to our students, because once they realized that the results of their achievement will not only be academic grades but profits and connections to the career field, they become more motivated to learn, more eager, alert and excited to this new experience,

which made them more accurate and cooperative than before”. More of the effects of the E-STEM model were explained by the BT who said, “STEM students were more enthusiastic to present the plans of their business ideas and many of them were open to the risk of a loss. Meanwhile, considering the profit made them empower all the competencies they have already developed during their STEM classes to achieve better results. All of this is considered a positive step towards entrepreneurial learning”. Additionally, the TT added, “I believe that this model will highly facilitate entrepreneurial learning because STEM students are more eligible than others to become entrepreneurs as they are inventors, so focusing on enriching their entrepreneurial skills will definitely be beneficial in all aspects such as personal and economical as well”.

In addition to that, the ST said, “The most important impact is on the personal side; I observed very clearly that students became more confident as they were very proud of their STEM designs that were created by them, and every day, they had stories to tell about their progress, problems and how they were able to solve or manipulate. This model charges their powers and gives them new positive souls of learning”. The experience of the MT indicated, “the consistent implementation of E-STEM model could enhance the self-employment because students are introduced to the process of organizing and assuming the expected risk of business.” Then she supported her perception saying, “Although only few students were actually able to experience profit making, most of the students enjoyed this learning model because they become more self-reliant and autonomous-learning oriented”. Accordingly, the BT recapped, “there is no doubt that E-STEM model was a very good educational practice that enhances students’ acquisition of many entrepreneurial competencies such as making a business plan, taking risks, experiencing the loss, and being more confident. In addition to that they gain awareness of the financial issues as well as the value of the product or the service they provide to the community.” More positive thoughts were emphasized by the TT who justified her positive belief towards the impact of E-

STEM model saying, “I think the E-STEM model can increase productivity and produce new technologies or create better services to the community, which accelerates the economic growth of the country because this model makes the students more aware of the value of innovative products. I personally observed a new learning disposition in our school, which reflected an important impact of this implementation, when I heard our students include the terminology of entrepreneurs in their daily conversation.” Finally, the ET summarized her opinion saying, “I believe that such a model is useful in many dimensions; It exposes students to a real learning experience where they can gain funds immediately. It allows students to safely make mistakes because they still work in a small budget at this stage, and this will help them learn from their wrong decisions when they decide to create their own business in the future. It enriches the learning environment with new participants such as parents and relatives who were as excited as their children to the idea of using the STEM designs to add value to the society. Generally, students were able to demonstrate the overall educational-value of E-STEM learning experience, as it was clear for me that they become more research-oriented, and that enhanced their reasoning and thinking skills. More importantly, entrepreneurship became a new learning disposition in the school.”

The ET observed a positive impact on the school community as she said “E-STEM model provides the students with a meaningful learning opportunity including the basic tools of the development of the industrial field. Not only that, I found many of the other students were inspired by the E-STEM students and were asking consistently about how they have reached this level”. The ST added, “practices of the E-STEM model made students rethink about the most important designs that are innovative as well as needed”. Furthermore, the BT who responded very positively to the interview questions said, “I totally believe that the entrepreneurial STEM education (E- STEM) can contribute to the innovation and entrepreneurial learning because my STEM class reflected a type of business session, my students suggested having a shop in the

institution to introduce and sell their designs and products. In spite of the challenges we faced, they were able to make the vending machine and gain some profit.”

- **Educational Reform through E-STEM Model**

Secondly, E-STEM teachers were asked about to explain if E-STEM model is a step forward in the UAE’s educational reform and a step towards better STEM implementation. All teachers agreed that this model supports STEM implementation as well as the educational reform in the UAE. Thus, the ET explained her agreement saying, “Yes, because UAE education aims to generate new students who are fully equipped with the competencies such as critical thinking, problem solving, persuasiveness and confident enough to face the challenges of the workplace as well as create more working opportunities to others in order to enhance the economic growth of the country”. Moreover, the ST emphasized, “the E-STEM model ensures not only that education for employment but also for self-fulfilment. We always tell our students that STEM education prepares them for their future careers. The E-STEM model provides them with an authentic opportunity to examine their abilities and competencies that are developed in the educational context”. Additionally, the MT who responded “Yes, the E-STEM model make my students have a new perspective regarding their STEM design because they were thinking about how to produce the best useful design that could help them make money, so, they become more motivated and determined to work cooperatively to achieve the task on time. Moreover, I observed that my students became more competitive as each group was working hard to deliver their designs to the best possible opportunity of business; also I found that the more integrated knowledge and practices from different disciplines, the more creative ideas, they are able to suggest for their STEM designs in order to solve a real problem.” The TT believed that, “the E-STEM model is a good initiative to support the educational reform in the UAE because it provides teachers with a clear framework of implementation. Usually, teachers receive new educational theories or programs without enough guidance on how to apply in the real classroom. The E-

STEM model is designed in a proper way that was very helpful to STEM teachers and facilitates their work.”

- **Advantages of E-STEM model**

Thirdly, teachers were asked about the main advantages of E-STEM model they have observed on their students. Two main themes identified to reduce the data (1) Classwork benefits and (2) Personal benefits.

- **Classroom Benefits**

The BT proudly expressed her experience saying, “I found that STEM education minimizes the effort I used to teach the business concepts to my students in isolation, because STEM students are highly prepared in terms of their skills and attitude to search, learn, take risks and accept failure and the idea of re-planning for better results. In short, STEM students are more skilled and better oriented to action”. Likewise, the ST found that “entrepreneurial practices applied in STEM classes made the students who are not interested in designing new products more motivated to be engaged in the entrepreneurial learning, especially in activities related to studying the market and examine the functionality of the products, so, each student was excited and interested in a certain stage, which better enhance the cooperative and collaborative work of each team.” Furthermore, the ET observed that, “all students were able to contribute to the development of this inquiry, which was the highlight of this valuable experience. They were collaborating enthusiastically to accomplish the task and consistently push for better. Some of them have accessibility through family connection to the market. Others were more interested in techniques of the design. Others were able to communicate and present the work. Working in teams and collaborating their capabilities make most of them engaged and enhance their strengths as well as improve their weaknesses”. Participating teachers agreed with the opinion of the MT who explained, “the best observation is that practices of the E-STEM model are well-structured which was very helpful for teachers to go through this new implementation and to focus on scaffolding students who are

working on ill-structured STEM tasks to enhance their higher-order thinking skills. Meanwhile, the ST described the E-STEM experience as, “a purposeful and exceptional learning experience because it focuses on being effective in all its stages and promotes further learning. Consequently, it launches the learners in the direction of being lifelong learners who pursue education out of school courses”.

- **Personal Benefits**

More interestingly, the BT described, “the beauty of E-STEM model was in the harmony found in the learning context because of the interaction between the teacher, the parent, and the student, to support the learning journey regardless of the results, which is a value by itself. For example, although a group of students designed a wonderful heat-isolated container and studied the market surrounded and planned their business, they were not able to sell their product and make profit; however, they decided to re-study the problem and re-plan to be able to communicate with the proper customer and enhance the interest to their work, which is an important skill that I am happy to see our students able to develop”. The ST explained that, “the most useful advantage is E-STEM implementation created a good opportunity for teachers to explore the entrepreneurial abilities as well as the talent of the students. Their ideas and projects were a big surprise to many teachers. I had no idea that our students have this potential”. Finally, the TT emphasized, “many students think that failing is always the end of the world; however, becoming familiar with the learning process of E-STEM and all its practices was quite a useful experience to all students because they mainly develop many learning competencies that cannot be acquired in the traditional learning sitting and they realized that attainment is not the only thing to pursue. It is great to teach our students that the value is in the learning journey itself”. Finally, all the E-STEM teachers totally agreed that students were motivating each other to keep working and to tolerate ambiguity of the unexpected challenges and they were using all the possible resources to support their entrepreneurial endeavour.

- **E-STEM Obstacles**

Fourthly, teachers were asked about the main difficulties they have faced during the implementation of E-STEM model and if they were able to overcome any of these obstacles. The five participating teachers' responses focused mainly on the implementation challenges. The ET admitted that, "the lack of time and many resources were the main obstacles of E-STEM implementation. This incorporation motivates the students to increase the complexity level of the STEM design to fulfil certain requirements in the market; however, the time given for E-STEM model was not enough to be completed for all students." Accordingly, the BT added, "some groups were not able to re-plan for their business project to avoid failing. All we could do is to promise them to continue working in the E-STEM projects next year that could provide them with more time to upgrade their STEM designs and their business ideas as well. Furthermore, some students decided to keep communicating during summer vacation and use their family relations to find better business opportunities and to prepare the required resources for the next academic year". On the other hand, the MT said, "STEM activities usually cut across many disciplines; however, it was my first time to experience integrating business practices. It was difficult for me to answer all students' questions because I was not aware enough of the concepts and knowledge. According to that, I asked the business teacher to support me. She quickly engaged in the process and her contribution was very valuable because she was able to better guide the STEM students not only on how to study the market, but also on how to select an appropriate design that is needed in the market or might add any value." Furthermore, the ST admitted that this model was challenging because it is not part of the regular STEM curriculum and incorporating entrepreneurial practices required time and facilities that were relatively limited, which negatively affected the flow of the standards that should have been covered in this academic year. That is why full support from the curriculum developer is urgently needed to be able to infuse the new practices into the STEM program."

- **Continuity of E-STEM learning in UAE Classes**

Fifthly, teachers were asked about if they are willing to implement E-STEM learning again in their classes. Four teachers responded positively to this question and asked for some changes and more support to enhance their implementation, while, only one teacher reacted negatively in her response. Thus, the TT said, “Regardless of the difficulties I faced to implement this model, yes, I would like to go through this project again because it worth trying and applying, but I think more administration support and facilities are needed to be able to repeat this model more effectively. My students wrote in their reflection that they have enjoyed this model and strongly preferred to be engaged again in its practices”. Moreover, the BT responded, “Yes, I am; however, the implementation will be much better if the entrepreneurial pedagogy is clearly integrated in the STEM curriculum in order to have unified E-STEM curriculum in order to better facilitate the implementation”. Adding to that, the ST replied, “Yes, I am willing to do that again, but E-STEM model needs more time to be implemented efficiently, so time and resources should be considered at the beginning of the academic year. Moreover, I appreciated the engagement of business teachers in the E-STEM implementation. I think it is more useful than teaching business in isolation because this incorporation gives more meaningful learning opportunities to STEM students”. On the other hand, the MT said “I am sorry to say, I am not willing to participate again in this model unless it is part of the unified STEM curriculum as it was challenging to focus on this extra work and complete all my teaching plans effectively. Unfortunately, the annual plan was negatively affected. I think E-STEM does not fit in with our regular teaching standards as it takes away time from important academic content”.

Table 28: Summary of Teachers' Beliefs regarding their E-STEM Model Experience

Interview	Summary of results
<u>Question 1</u> 1. What is the impact of the implementation of the E-STEM on the students' learning outcomes?	Participating teachers found positive impacts of E-STEM model on both personal and community sides. • Students' intrinsic motivation and attitude are enhanced as they become more enthusiastic to learning through engaging in real life business and work to add value or gain profit. • Many of the students' entrepreneurial competencies were developed such as reasoning and thinking skills, communication, collaboration, confidence, risk-taking, independence, research, business plans, financial awareness, productivity, innovation, creativity, sociability, and to experience both loss and profit making. • Other students in the school were inspired by E-STEM students and show interest to implement such a model.
<u>Question2</u> 2. Do you believe that the new E-STEM model is a step forward in the UAE's educational reform and a step towards better STEM implementation? Explain.	• Teachers agreed that E-STEM model facilitates the education reform in the UAE that aims to connect learning experiences to real life needs because E-STEM produces more students who are entrepreneurially literate through creating more working opportunities for them and others. • There is a consensus that E-STEM model changes students' perspective regarding STEM designs or outcomes as they better value their work to become competitive. • Integrated knowledge and practices of entrepreneurship and STEM allowed students to think more creatively to solve real life dilemmas.
<u>Question 3</u> 3. What are the main advantages you have observed of the entrepreneurial-	E-STEM teachers observed that many of their students collaborated better to achieve their tasks in the given time. More importantly, group capabilities were unified where everyone contributed and engaged in the learning development. The most highlighted advantage of the E-STEM model is that students get to understand that pursuing for further learning experiences is as valuable as pursuing for better attainment and generates more lifelong learners. E-STEM model is a well-structured instruction that provides teachers with a clear guidance to implement it through ill-structured learning problems that enhance students' thinking. Moreover, parents were involved in the learning process side by side with the teachers to support the students. Further, E-

STEM model on your students?	STEM is an opportunity for teachers to explore the entrepreneurial abilities and talent of their students.
<u>Question 4</u>	
4. What are the difficulties you have faced during applying the E-STEM model? Did you overcome any of them?	• First, administration challenges are highlighted such as • Limited time and lack of resources • Lack of teachers' knowledge about entrepreneurial learning • Moreover, implementation challenges are identified such as: • E-STEM is not included in the attained curriculum, which hampered the coverage of the curriculum and reduced the achieved standards.
<u>Question 5</u>	
5. Are you willing to implement E-STEM model again in your class? Why?	All teachers showed interest and willingness in implementing E-STEM model again, only if they received enough support from the administration to reduce the effect of obstacles and challenges, they faced. Besides, they believed that engagement of business teachers is needed for better integration of knowledge

4.2.2 Results of E-STEM Students Questionnaire

The purpose of the students' questionnaire that was given to students after implementing E-STEM practices is to examine the relationship between E-STEM practices and students' entrepreneurial competencies. Thus, the Statistical Package for Social Sciences (SPSS) is used to analyse the quantitative data of the study. First, the reliability test was measured for each variable and all items of the questionnaire, followed by the factor analysis to test the validity of the proposed variables. Finally, comparison of mean scores that were collected through quasi-experimental design of the control and experimental groups was done to then test the study hypotheses by correlation and regression analysis. Thus, the questionnaire was

developed, distributed and the data was inferentially analysed to answer the following research question

- What is the effect of E-STEM practices on students' entrepreneurial competencies?

Quantitative Data Analysis

The assumption of using parametric tests was tested by a Shapiro-Wilk's test ($p > .05$) that showed that the test scores were approximately normally distributed for all variables in the control and experimental groups (Appendix 13). Accordingly, independent t-test was conducted.

Results of Quasi-Experimental Groups

The quantitative data collected from the control and experimental groups were analysed in the following sequence: Firstly, testing the effect of the E-STEM practices (independent variable) on entrepreneurial competencies of students (dependent variable). Therefore, the independent t-test was used to analyse and compare the mean scores of the pre-tests as well as the post-tests of both groups separately in order to determine the equivalency of their results and the adequacy of sampling. Secondly, the current investigation was conducted to test the effect of one independent variable (E-STEM practices) on students' competencies of two different groups (control and experimental). Consequently, Paired t-test was utilized in SPSS as an inferential statistic test to compare the mean scores of the dependent variables (knowledge, skills and attitude) between the pre-test and post-test of the two groups to measure any statistically significant difference found. Finally, cause and effect relationship between the independent variable and the dependent variables through applying the correlation test was measured to compare the p value of the two groups.

Equivalency of experimental and control groups

The quasi-experimental design was conducted by recruiting 113 high school students in six classes (2 classes of grade 11 boys), (2 classes of grade 11 girls) and (2 classes of grade 10 girls) who were all implementing E-STEM model under the supervision of the same five teachers. The intact groups or classes were assigned randomly to apply two different treatments. The first treatment is implementing E-STEM model with 58 students divided into three classes (16 boys and 42 girls) while the second treatment is applying the regular STEM curriculum without incorporating entrepreneurial practices into its coursework with 55 students in another three classes (19 boys and 36 girls). The six groups of two different treatments were pre-tested to compare their results and study the equivalency of subjects. The following table shows the results of comparing the pre-tests mean scores of all the variables of the study using an independent t-test.

Table 29: T-test Comparison of Pre-tests Scores for both Control and Experimental Groups

Pre-tests Comparison of mean scores						
Variables	Group	N	Mean	SD	t	Sig.
Knowledge	Control	55	15.95	2.67	.434	.510
	Experiment	58	15.72	2.75		
Skills	Control	55	37.96	3.84	.620	.536
	Experiment	58	37.50	4.10		
Attitude	Control	55	16.47	2.94	1.02	.311
	Experiment	58	15.93	2.73		
Entrepreneurial Competencies	Control	55	70.38	6.18	1.04	.301
	Experiment	58	69.16	6.36		
E-STEM Practices	Control	55	59.58	5.75	.511	.610
	Experiment	58	59.02	5.99		

Table 29 presents the statistical comparison that indicated that there is no significance difference in the pre-test scores of both control and experimental groups regarding their independent variable (E-STEM practices), where the control group achieved (M= 59.58, SD= 5.75) and experimental group achieved (M= 59.02, SD=5.99) and the $p=.610$. With respect to the dependent factor (entrepreneurial competencies) for the control group (M= 70.38,

SD=6.18) and experimental group (M=69.16, SD=6.36) with $p = .301$, which also reflects that there is no significance difference between the groups. The competencies identified in the study include knowledge, skills and attitude. When analysing each variable separately, the variable of (Knowledge) for the control group was (M= 15.95, SD= 2.67) and the experimental group (M=15.72, SD=2.75), with $p = .510$. The variable of (Skills) achieved (M= 37.96, SD=3.84) for the control group, while the experimental group obtained (M= 37.50, SD= 4.10) with $p = .536$. Lastly, the variable of (Attitude) was similar to all other variables and obtained no statistically significant difference between the groups, where the control group was (M=16.47, SD=2.94) and the experimental group (M= 15.93, SD=2.73) with $p = .311$. Consequently, it can be concluded that there is no significance difference in terms of the mean scores of the pretests conducted for control and experimental groups across the variables because the groups shared the same starting point before the treatment. These results proved that the current groups of participating students were appropriate to carry out the study and fulfill its purpose.

4.2.3 Results of testing E-STEM Model

The current study hypothesized that the implementation of E-STEM practices that infuse entrepreneurial practices into STEM education can influence students' entrepreneurial competencies including knowledge, skills and attitude.

Comparing the groups' total mean scores of the two tests

Table 30: T-test Comparison between Pre & Post-tests of the Total Scores of the Two Groups

Pre & Post-tests Comparison of the total mean scores							
Model	Group	Test	N	Mean	SD	t	Sig.
E-STEM	Control	Pre Post	55	129.96 129.09	7.95 9.11	.658	.513
	Experiment	Pre Post	58	128.17 150.52	8.291 10.13	-12.75	.000

Table 30 presents the results obtained from the Paired t-test to compare the total mean scores of the pre and post-tests of each group separately. With respect to the control group, the values of standard deviation slightly increased and the mean scores were fairly equal between the pre-test before the regular STEM treatment (M= 129.96, SD= .658) and the post-test (M= 129.09, SD= 9.11), with an insignificant value of $p = .513$, contrary to the results of experimental group where the pre-test scores before the treatment (M= 128.17, SD= 8.291) and the post-test scores after the E-STEM treatment (M= 150.52, SD= 10.13) with a highly significant value of $p = .000$. These findings indicated that there is a significant improvement in students' entrepreneurial competencies after the implementation of E-STEM model. On the other hand, students' competencies in the control group who did not experience incorporated entrepreneurial competencies into their STEM curriculum did not improve significantly.

Comparison of Post-tests' scores of the two groups

Independent t-test was used again to compare the mean scores of each variable (knowledge, skills, attitude and entrepreneurial competencies) in the post-tests between the control and experimental groups.

Table 31: T-test Comparison of Post-tests Scores for both Control and Experimental Groups

Post-tests Comparison of mean scores						
Variables	Group	N	Mean	SD	t	Sig.
Knowledge	Control	55	16.20	2.81	-6.1	.000
	Experiment	58	19.00	2.00		
Skills	Control	55	37.96	4.01	-2.08	.040
	Experiment	58	39.43	3.48		
Attitude	Control	55	16.69	2.63	-6.56	.000
	Experiment	58	19.79	2.38		
Entrepreneurial Competencies	Control	55	70.85	5.78	-6.40	.000
	Experiment	58	78.22	6.42		
E-STEM Practices	Control	55	59.09	5.47	-14.9	.000
	Experiment	58	72.29	4.63		

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

*Correlation is significant at the 0.05 level (2-tailed).

Table 31 shows statistical results that indicate high significance difference among all variables between the two groups, which means that the effect of the treatment (E-STEM practices) is significant $p < 0.05$. The significant value obtained to confirm the difference in mean scores for all variables is obviously high $p = .00$; however, the significant value $p = .04$ regarding the difference between means of the variable of skills between the control and experimental groups is not as high as all other variables (E-STEM practices, knowledge, skills and attitudes). Moreover, the mean scores of the experimental group of all the variables tested is greater than those of the control group, while, the standard deviation of all variables of the experimental group is less than the standard deviation of the control group. This reflects greater variation of the means of STEM students than the means of the E-STEM students. These results support the study hypothesis that incorporating entrepreneurial practices into STEM education better enhances students' entrepreneurial competencies, rather than only relying on STEM.

Summary of Results

The following table 32 demonstrates a summary of the integrated results collected from qualitative phases in both exploratory and confirmatory stages of the study in the light of participants' views, beliefs and perceptions. The summary aims to identify and represent the main points and key details provided for each theme to support the discussion of findings. Thus, academic leaders who are responsible for the implementation of STEM curriculum in the participating campuses are called 'STEM academic leads.' This includes the curriculum developer and the lead teachers of each discipline of STEM. Moreover, 'STEM teachers' refer to all subject teachers who are participating in the implementation of STEM course in the schools. Finally, 'E-STEM teachers' refer to the five main subject teachers who implemented E-STEM model in their classes.

Table 32: Integrated Results from Exploratory and Confirmatory Stages

Pedagogy (Why incorporating entrepreneurial practices into STEM education is possible and desirable)				
Qualitative responses of the exploratory stage	STEM Leaders' knowledge regarding entrepreneurial learning	STEM Academic Leaders' views		Contribution of STEM to entrepreneurial learning
		Few of STEM leaders (only business leaders) were able to identify and perceive entrepreneurial learning because it is not included in the applied STEM curriculum.	It can generate more scientific entrepreneurs because it enhances the students' acquisition of competencies needed for being an entrepreneur.	
	Incorporating entrepreneurial practices into STEM education	Majority of leaders believe that STEM education should be restructured to purposefully incorporate entrepreneurial pedagogy and practices into its curriculum and STEM teaching and learning instruction respectively.	STEM leaders mentioned many obstacles:	Barriers of incorporating entrepreneurial practices into STEM
			-Lack of teachers' knowledge and students' innovative products - Limited time and resources - Entrepreneurial practices are not included in the intended curriculum	
	STEM practices that enhance students' entrepreneurial skills	STEM Teachers' perceptions (before E-STEM implementation)		Teachers' suggestions to enhance incorporating entrepreneurial practices into STEM education
		Teachers agreed that they implement practices such as planning, discussing, collecting and analysing data, integrating technology, making and evaluating projects, giving feedback in the light of design-based problem solving that	STEM teachers suggested involving business teachers to facilitate integrating entrepreneurial practices with the existing STEM course instruction. Apply experiential learning activities that focus on this incorporating	

		combines problem and project-based learning to develop students' skills, which all are considered entrepreneurial competencies	through extra-curricular practices and establish a new school department that coordinates the integrated practices of both STEM disciplines and business.	
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Practice (How entrepreneurial practices can be actually integrated with STEM practices)

STEM Teachers' Perceptions (before E-STEM Implementation)			
Effective STEM Practices that enhance entrepreneurial learning	Current STEM Practices	Practices of highest (89% to 96%) and medium (80% 88%) rate implementation are all related to design-based problem solving strategies like students cooperate in STEM teams, apply technology, integrate information from the S, T, E, M to design a new product, discuss and present their projects, take responsibility for learning, reflect on their experiences, evaluate their project, consider teachers' feedback to improve, identify the problem for investigation, think logically to solve a problem and (49%) make designs that add values. While, the lowest (< 30%) rate implementation came for practices related to entrepreneurial learning like studying the market and calculate the costs of the proposed STEM project.	
	Suggested Practices	Suggested practices with high emphasis are establishing a new department of entrepreneurship programs to incorporate entrepreneurial practices into existing course curriculum with the support of business teachers (94%). Majority of STEM teachers (80% to 90%) recommended (summer school programs, extracurricular activities, hands on experience to start new business and visiting companies to allow students communicate with the market) While suggested practices with less emphasis (< 80%) are (inviting guest speaker, computer simulation) respectively.	

Quantitative responses of the exploratory stage	Barriers of incorporating entrepreneurial practices into STEM		Over (80%) of STEM teachers emphasized that lack of teachers’ knowledge, difficulty of assessing entrepreneurial learning and limited time are the most important challenges of incorporating entrepreneurial practices into STEM education
	The effect of teachers’ demographics of their responses	Academic qualifications	The mean scores of effective practices of STEM teachers of high academic qualification (master’s degree) are more significant than others with less academic qualifications
		Subject taught	The differences between the mean scores of effective practices ($p= .000$) as well as obstacles ($p< .05$) attained by engineering teachers are statistically significant in comparison to all the other three-subject teachers
		Teaching experience	The mean scores of effective practices of teachers with long teaching experience (more than 10 years) are more statistically significant than other teachers with short experience of teaching.
Outcomes (Impact of E-STEM implementation on students’ entrepreneurial learning)			
		E-STEM Teachers’ Beliefs (after E-STEM Implementation)	

Impact of E-STEM on students' learning outcomes	Teachers found positive impact of E-STEM model regarding • Personal benefits (students' intrinsic motivation, attitude, and development of entrepreneurial competencies) are enhanced through the implementation of E-STEM model • Community benefits: (other students were inspired and show interest to the participate in the practices of E-STEM model)	Teachers believed that E-STEM model enhanced students' engagement, contribution and collaboration to achieve their learning projects. They become more competitive and learning-oriented than attainment seekers. Besides, the involvement of parents in the learning process becomes more effective. E-STEM is a well-structured instruction that provides teachers with the opportunity to explore the students' entrepreneurial abilities and talent.	Advantages of E-STEM model implementation
E-STEM model is a step forward in STEM education reform	Teachers agreed that E-STEM model facilitates education reform in the UAE and changes students' perspectives about their design to become more competitive in the market. Besides, integrated knowledge and practices allow students to find creative solutions to real life dilemmas. Moreover, the structure of E-STEM framework facilitates teachers' implementation.	Despite of the good structure of E-STEM model, it is time consuming, especially, if it is not involved in the curriculum plan. Both administration and implementation challenges were found such as time management, teachers' knowledge and the difficulty in covering the required number of curriculum standards.	Challenges of E-STEM model implementation

	Teachers' willingness to implement E-STEM model	Teachers showed interest in implementing E-STEM model again with the business teachers' collaboration, and they emphasised their need to the school administration's full support to be able to overcome the challenges they faced during the implementation of E-STEM model.
	The relationship between E-STEM practices and students' entrepreneurial competencies	E-STEM Students' Perceptions Practitioner teachers of E-STEM observed the relationship between students' entrepreneurial competencies and E-STEM practices conducted in their classes. They explained that STEM students were able to determine their abilities and they were working enthusiastically to develop the entrepreneurial set of competencies introduced to them.

CHAPTER 5: DISCUSSION

Incorporating entrepreneurial practices into STEM education in the UAE has a positive impact on enhancing entrepreneurial core competencies of students. The current inquiry conducted through two main stages (exploratory and confirmatory) to fulfil the main study's purposes. The academic leaders' and teachers' engagement in the education reform that primarily give great attention to STEM education is very important to produce a new generation of innovators and entrepreneurs in all fields in the country (UAEinteract 2015). Therefore, the exploratory stage aimed to explore academic leaders' views regarding this incorporation and explain teachers' perceptions about the most effective practices within STEM education that enhance incorporating entrepreneurial practices into STEM education which all lead to developing the integrated practices-based model. In accordance with the discussed literature, the previous academic perspectives reflect the desire and the need to investigate new pedagogical models that enhance incorporating entrepreneurial practices into STEM education with high school students because it is never too early to acquire some soft entrepreneurial competencies (Warhuus & Basaiawmoit 2014; Winkler et al. 2015). Thus, the confirmatory stage aimed to examine the educational model (E-STEM) developed in the light of the results of the first stage through investigating the cause-and-effect relationship of the E-STEM model implemented as a treatment on promoting high school students' entrepreneurial core competencies. According to Professor Akintoye, both conceptual and theoretical frameworks can guide the interpretation and explanation of the data collected (Adom et al. 2018).

Data gathered qualitatively and quantitatively from the two stages was integrated and discussed to fully answer the study questions in the light of the main elements (pedagogy, practice and outcomes) of the conceptual framework, which is informed and strongly supported by the theoretical framework of the study. In addition to the discussion of the study results, this section

introduces the conclusion, implications, recommendations for future research agenda, and the limitation of the study as well.

5.1 Pedagogy

Pedagogy refers to the relevant theories and practices that help deliver a specific academic content to students. Thus, the study focuses on the pedagogy that reflects the possibility of incorporating entrepreneurial practices into STEM education, and then help support the creation and the development of E-STEM model. The literature concerning entrepreneurial learning argued that if the noble educational objective is to transfer learning experience into real-life applications, then constructing students' entrepreneurial identity needs to be emphasized as a goal to enhancing their learning skills (Donnellon, Ollila, & Middleton 2014). Further, the current study supports the argument that education reform should prepare future students for unstable employment through emphasizing the implementation of integrated curricula (Shaer et al. 2019).

5.1.1 Pedagogical Strategies of E-STEM Learning

Participating academic leaders believe that stability of the employment process is not granted anymore, therefore, students should be provided with learning opportunities that promote their knowledge and skills to be self-employed. This meaning is consistent with Ezeudu et al. (2013) as well as Costa et al. (2016) who mentioned the instability of the employment flow and emphasized that students' entrepreneurial competencies should be targeted to help cope with the future challenges. In this regard, Hershman (2016) suggested restructuring STEM education to incorporate entrepreneurial practices into its curriculum to make use of STEM efforts by delivering its learning designs to the market. Moreover, Winkler et al. (2015) assumed that entrepreneurial practices could be effectively infused into existing STEM programs in order to develop entrepreneurial learning of STEM students with no evidence found in the literature to how this incorporation can be implemented in the high school.

Since pedagogy adopted by teachers shaped their instructions in the classroom (Hargreaves 2004). It was critical to explore STEM leaders' views regarding incorporating entrepreneurial practices into STEM education in the context of the UAE. The results reflected that STEM academic leaders believe in infusing entrepreneurial pedagogies into STEM curriculum and integrating entrepreneurial practices with STEM teaching and learning instructions with the constant support of business teachers because they are more aware of the entrepreneurial learning activities than other teachers in the school. This view is consistent and corresponds to the opinion of the European Commission (2003) that suggested integrating entrepreneurial practices with different disciplines as a general learning attitude that can be implemented in all school activities to foster students' entrepreneurial spirit. According to the perspective of both participating leaders and previous researches found in the literature, the focus of STEM education should be broadened and expanded to situate STEM practices and curriculum elements within a business context. These results are not only consistent with Winkler et al. (2015)'s suggestion of incorporating entrepreneurial practices into STEM education, but also responsive to its dilemma because it offers a practical solution (E-STEM model) of how this incorporation could be done effectively in high school classroom, which constructs a new learning trend in education called 'integrated E-STEM learning'. The main principles of this learning model derived from the pedagogical strategies of both STEM education and entrepreneurial learning.

Furthermore, STEM academic leaders believed in the positive impact of STEM education on entrepreneurial learning because engaging STEM students in entrepreneurial practices could produce a new generation of entrepreneurs who are scientifically, mathematically and technologically literate which will upgrade their abilities from being not only inventors to become both inventors and entrepreneurs. Since, they agreed that not all scientists are entrepreneurs, and STEM courses taught in UAE schools are not enough to generate future

entrepreneurs because the current STEM learning focuses mainly on inventing but not marketing. They have acknowledged the need to support the STEM reform in order to better enhance students' acquisition of the other entrepreneurial competencies required for their future careers. This result matches Forawi (2014) who suggested providing UAE students with more meaningful learning experiences that focus on aspiring their future career choices. In other words, school learning practices should be connected to real job tasks even if the student is distant to the employment or work responsibilities (Anwari et al. 2015). Thus, the discussion between lead teachers created a consensus that STEM education can be a valuable step in the preparation for entrepreneurship education as it helps equip the students with the necessary tools to be introduced to entrepreneurial knowledge because when students are already STEM educated they are going to be more skilful, ready and motivated to learn about entrepreneurship. According to the entrepreneurship intention model, entrepreneurial learning is directly linked to the acquisition of entrepreneurial knowledge, which is considered as one of the key elements responsible for motivating students to act entrepreneurially.

5.1.2 E-STEM Learning Environment

Moreover, STEM lead teachers elucidated that the characteristics of the learning environment needed for both STEM and entrepreneurship education are relatively similar, because experiential learning through hands-on activities is the best approach for both of them, where authentic learning opportunities are provided to students to be engaged in real-life practices (Volery et al. 2015). STEM academic leads also clarified that they often focus on applying both project-based learning and problem-based learning in STEM classes because they are recommended as effective pedagogical strategies to support the UAE national innovation agenda (UAE Vision 2021). This recommendation corresponds to a substantial quantity of research that emphasize the effect of these strategies on producing meaningful outcomes of STEM education (Edmunds et al. 2017; Capraro et al. 2013; Sahin & Top 2015; Wihelm 2014;

Lansiquot et al. 2011; San et al. 2018). This reflects that UAE schools are committed to apply and master the pedagogical practices recommended by the Ministry of Education. At the same time, utilizing project and problem-based entrepreneurial learning approaches help students gain the basic skills needed to act entrepreneurially (Sousa 2018). Moreover, (Bruyat & Julien (2001) agreed that the notion of entrepreneurial value creation could result in development of entrepreneurial competencies because it enhances students to learning knowledge, acquiring skills, motivating attitudes that all can be used to facilitate business start-up. The consistent implementation of E-STEM model is supported by the trilogy of success in learning for Campbell et al. (2004) who explained that educational practices that emphasize the engagement (awareness, interest and motivation), the capacity (knowledge and competencies) and the continuity (learning opportunities, resources and desired outcomes) enhance students to show progress in the learning path of STEM. The results reflected that the implementation of E-STEM model reshaped the environment of the STEM context to be business like.

The key insight behind emerging entrepreneurial practices into STEM education is that students' school experiences, their future decisions and intentions do not rely on collecting knowledge and applying abstract principles to judge theoretical dilemmas (Johnson 1993). Rather, it requires consistent and authentic engagement with real problems in which they might find themselves immersed in the near future. Therefore, the E-STEM model was developed as a result of the exploratory stage's finding and according to teachers' perceptions, it provided STEM students with meaningful learning practices to experience being entrepreneurs. At the same time, it is supported by the perspective of Kyndt & Baert (2015) who believed that entrepreneurs grow as learners because their learning outcomes rely better upon going through both educational and real-life experiences in a student-centred environment. Based on situated cognition theory, the learning process of the E-STEM model in the light of design-based approach is relevant and authentic because it is grounded within practice-based context that

capitalizes on the situated E-STEM learning where engineering design (Kelley & Knowles 2016) and planning to create a value through delivering STEM outcomes to the market form the new situated context. In the light of Jacob (1989), E-STEM model creates new elements of an interdisciplinary curriculum that consciously applies integrated practices from different disciplines (entrepreneurship and STEM) to examine new learning experiences.

5.1.3 Main Challenges of E-STEM Learning

This study explored and explained teachers' perceptions regarding the challenges of incorporating entrepreneurial practices into STEM education. The results showed that the most important challenges reported by participants from STEM academic leaders as well as teachers is the weak background of entrepreneurial knowledge and skills of STEM teachers as opposed to project and problem-based learning. This reflects the urgent call for teachers' professional development programs that focus mainly on the implementation of integrative approach-based practices to avoid the anticipated negative effects such as potpourri and polarity effects of ill-structured instruction (Jacob 1989). Entrepreneurship literature explained that diffusing entrepreneurial activities to all students of different streams is a real challenge that requires interdisciplinary approach to raise students' awareness of entrepreneurship and to develop their abilities (Wilson, 2008). Despite the consensus of leaders to the possibility of infusing entrepreneurial practices into STEM education in the UAE, they believed that there are many other challenges that could eliminate the success of this integration such as limited administration support, inadequate time and resources and the difficulty of assessing entrepreneurial practices. Besides, E-STEM is not included in the attained curriculum, which hampered the coverage of the curriculum and reduced the achieved standards. Results collected from STEM teachers also confirmed these barriers, and reflected teachers' need the full support from the school administration to be able to implement E-STEM practices more effectively. This result also indicates the importance of reducing the curriculum load that focuses mainly

on academic subject knowledge to provide teachers with enough space to be able to implement the new competencies-based model. Consequently, all participating teachers showed interest and willingness in implementing E-STEM model again in their classes, only if they receive enough support from the administration to reduce the effect of the obstacles they faced.

Evidently, the inferential statistics revealed a statistically significant difference between STEM teachers' responses based on their academic qualification, teaching experience and subject taught. Contrary to the effect of gender and Emirate of the participating teachers that did not reflect any significant differences between their responses in relation to the effective practices that enhance incorporating entrepreneurial practices into STEM education as well as to the challenges of applying this incorporation. According to the meta-analysis of Hedges et al. (1994), teacher qualifications are positively related to teaching practices and students' outcomes. That is why, teachers with better academic qualification like master's degrees as well as long STEM teaching experiences provided more positive responses to the incorporation of entrepreneurial practices into STEM education. The more teaching experience, the better STEM practices applied, which in turn affect students' STEM outcomes. Moreover, engineering teachers contributed more positively to the study questions because they are more engaged in the part related to students' STEM designs. This result supports the need for professional development programs for teachers to enhance their competencies that will be brought into action in everyday practices.

5.1.4 Philosophy of E-STEM Learning

Business literature explained that it is very difficult to identify the required competencies of future careers that do not exist now (Falco 2016), which means that developing and mastering entrepreneurial competencies during the different educational stages will open work

opportunities for individuals who did not develop other competencies needed for unknown careers. The primary focus of entrepreneurial learning is shifted from content to pedagogy in the lower levels of education to develop students' entrepreneurial skills (Pepin 2012) because it is not easy for high school students to convey the entrepreneurship content to the market. According to this discussion, E-STEM should be conducted in the light of education-through entrepreneurship to enhance teenagers in high school to experience STEM design-based business activities. Results of the study support this perspective because participating students in high school were able to achieve their E-STEM projects successfully through focusing on the learning process that emphasizes the value creation more than venture creation (Moberg 2014).

Therefore, the current study adopted the theoretical perspective relies upon education through entrepreneurship to investigate the effect of integrating entrepreneurial practices into STEM education on enhancing high school students' entrepreneurial key competencies, which are perceived as abilities that enable students to solve real-world problems successfully with respect to opportunities and challenges that might be raised (Wiek, Withycombe & Redman 2011). Following Lackeus's perspective regarding the focus of entrepreneurial learning in each educational stage, the acquisition and reinforcement of high school students' competencies (knowledge, skills and attitude) to be able to behave in an entrepreneurial way in their future is highlighted in this inquiry. Thus, the study aimed to develop and present an educational model (E-STEM) where entrepreneurial practices that encourage students to plan for value creation or business start-up are infused into an existing STEM program in high school. The following figure demonstrates the pedagogical philosophy of the E-STEM model.

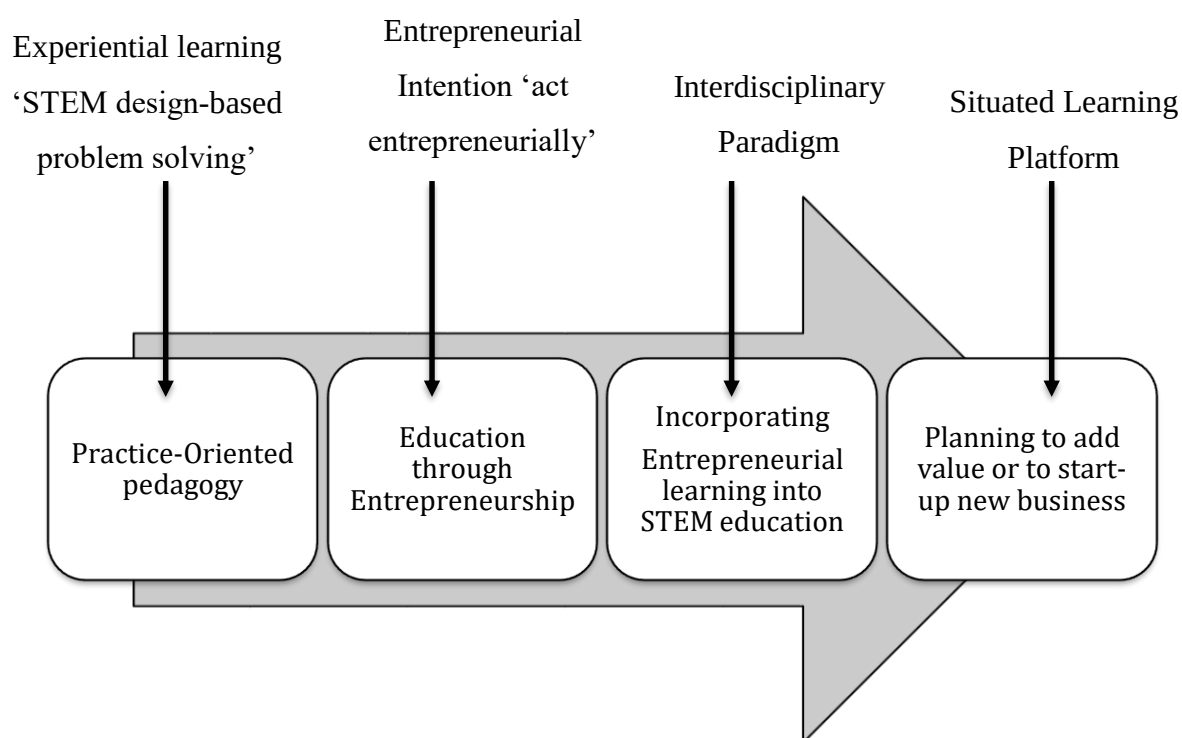


Figure 18: The Trend of the Entrepreneurial Incorporation into STEM Education in High School

Figure 18 explains that practice-oriented pedagogy is adopted to implement education through an entrepreneurship approach to promote students' entrepreneurial core competencies, which is supported by the experiential learning theory (Kolb & Fry 1975). Education through entrepreneurship is the relevant approach to engage high school students of STEM in entrepreneurial activity through focusing on the development of skills rather than content knowledge (Moberg 2014). Thus, integrated practices are utilized to incorporate entrepreneurial learning into STEM curriculum (Jacob 1989), which creates E-STEM model as a new situated learning platform (Lave 1988) in order to allow STEM students to plan to add value to their societies or start-up new business.

5.2 Practice

Sidhu et al (2018) argued that the majority of pedagogical frameworks of STEM disciplines focus more heavily on teaching the theoretical foundation and the basic concepts of each

course. However, current teaching instructions applied in STEM subjects are clearly broken because of the discrepancy revealed in the students' mindset and skills developed and the proposed ones that are needed to actual real-life problems. E-STEM teachers incorporated entrepreneurial teaching practices into the existing STEM courses applied in their school, and the results reflect overwhelmingly positive feedback from both teachers and students regarding this implementation. This result supports the purpose of the current study to incorporate entrepreneurial practices into STEM education in high schools in the UAE. With the aim of broadening the structure of STEM education to include entrepreneurial practices, the current study provided a nuanced understanding of the nature of this incorporation through the development of E-STEM model.

5.2.1 Current Effective Practices of E-STEM Learning

Academic participants stressed their beliefs regarding implementing project and problem-based learning or what they called design-based problem solving. This approach allows students to take responsibility for their learning in order to implement different essential practices in the STEM classes that enhance their cognitive abilities such as integrating information from STEM disciplines to create a STEM design. Furthermore to, identify a problem and post their own questions to guide the inquiry process, plan to collect the required data, cooperate and collaborate in STEM teams, being engaged in a logical reasoning process to enhance their thinking skills, use design rubrics to evaluate their STEM projects, keep reflecting on their learning to be able to modify their plans, use teachers' feedbacks to improve their products, discuss, argue and present their projects to the classmates. Anderson (1980) explained that solving problems requires conducting a sequence of cognitive operations to make reasonable decisions. A substantial amount of literature confirms that problem-based learning and project-based learning strategies are the most successful strategies used in the classroom to enhance meaningful outcomes of STEM education (Edmunds et al. 2017;

Capraro et al. 2013; Sahin & Top 2015; Wihelm 2014; Lansiquot et al. 2011; San at al. 2018) because they enhance students' acquisition of cognitive skills. Moreover, Ronis (2008) asserted that all these pedagogical approaches are derived from constructivism theory because these learning strategies provide students with valuable opportunities to work together to make use of their prior knowledge and independently plan and cooperate to construct new knowledge (Froebel 1887), which is supported by Vygotsky's perspective of social cognitive theory.

The previous result of the exploratory stage explained how the regular STEM classes focus more deeply on design-based problem-solving practices. Nevertheless, results of the confirmatory stage revealed that incorporating entrepreneurial practices into STEM education via E-STEM implementation gave more opportunities to STEM students to make use of their designs in order to add value to their societies and work to solve a real problem. Meanwhile, teachers who implemented E-STEM explained that different effective strategies and outcomes appeared across all the participating students such as the cooperation between the collaborative groups of students with a proactive attention to the E-STEM design-based problem solving, team planning that focuses on producing valuable STEM designs to gain profits, the expansion of the learning community and networkability including teachers, parents, friends and acquaintances. Also, to collect more relevant data that supports the E-STEM project, utilizing the integrated knowledge from different disciplines and the desire to learn more about the successful entrepreneurial activities, students were motivating each other to tolerate ambiguity of the challenges they faced to keep working on the task. The conceptual framework of E-STEM instruction requires some aspects such as project-based problem solving, independent and cooperative learning, the communication between the internal community of the school and the external community. According to these results, E-STEM model lends itself perfectly to integrated knowledge and practices-based pedagogy and its

implementation should be explored and investigated by STEM leaders and decision makers in UAE education who are interested in enhancing a high level of students' autonomy in learning.

However, entrepreneurial practices that concentrate on creating new value or starting up new business were not similarly implemented in the STEM classes such as using STEM designs to create or add value to the society by making service or gaining profit, studying the markets' needs and calculating the costs required for each STEM product or design. On the other hand, Chandler & Hanks (1994) explained that the development of students' entrepreneurial competencies requires scanning the surrounding environment in order to select and make advantage of potential business opportunities by setting strategies of implementation, which means that students should experience entrepreneurial practices to enhance their abilities and willingness to perform entrepreneurially when creating new value for other people (Sánchez 2011, Burgoyne 1989, Kraiger et al. 1993, Fisher et al., 2008). That is why, E-STEM model was developed to ensure incorporating such entrepreneurial practices into STEM education. Mayer (2004) explained that integrated knowledge-based constructivist learning has its potential for enhancing the academic learning environment. Accordingly, interdisciplinary E-STEM model as an example of integrated knowledge and practices can suit different learning strategies such as PBL and PjBL or a design-based problem solving

5.2.2 Suggested Practices for E-STEM Learning

More interestingly, STEM academic leaders were asked to list a group of suggested activities to promote incorporating entrepreneurial practices into STEM education in the UAE. In order to expand this data, this list of suggested practices was delivered to STEM teachers in different Emirates through the questionnaire to explain their perceptions. The results reflected that there

are many ways that can help incorporate entrepreneurial practices into STEM education in high school. All of the suggested practices are relevant and applicable to achieve the required integration such as the establishment of a new department in the school to be responsible for planning and applying E-STEM practices that can be conducted both during the school year or as summer programs to focus on the engagement of STEM students in business tasks. Moreover, entrepreneurial learning could be supplemented with extracurricular activities. Hands-on experience related to businesses start up activities for group work as well as company visits through regular trips to communicate with the real market were all suggested by participants to enhance incorporating entrepreneurial practices into STEM education and to expand the limited communication opportunities provided to high school students with the workplace. Thus, the study found that students' engagement in real entrepreneurial practices could help them understand the value of their STEM designs and to motivate them to introduce new innovative ideas to satisfy the markets' needs.

The in-depth discussion with the STEM academic leaders reflected the need for practicing some entrepreneurial activities such as guiding STEM students to determine their abilities in order to form collaborative groups, to brainstorm their ideas in order to decide on the best design that add value to their communities, to use SWOT analysis to identify the strengths, weaknesses, opportunities of success and even the expected threats to their projects as well as to identify the available resources that help achieve their designs, and to construct a prototype to examine or create interest in their projects. Forawi (2014) suggested enriching students' learning experiences to aspire their choices. Accordingly, all these entrepreneurial practices mentioned by participants were incorporated into the regular practices of the STEM existing course to develop the new E-STEM model. Incorporating the participants' suggested practices created a platform that clearly supports the three key aspects (learning context, authentic

activities and the culture) that are naturally linked to the situated cognitive theory (Brown et al. 1989).

5.2.3 Building Blocks of E-STEM Learning

The theoretical model of Dietrich et al. (2015) was perceived as advantageous because its level of generality is relatively high. Educational models like E-STEM that target cognitive competencies can make use of this model and draw on its framework. Accordingly, the current study draws on the input-operation-output framework to perceive the new E-STEM model. Guided by the theoretical perspective of Dietrich's building blocks of scientific competencies in the social sciences, the following figure shows the theoretical building blocks of E-STEM model.

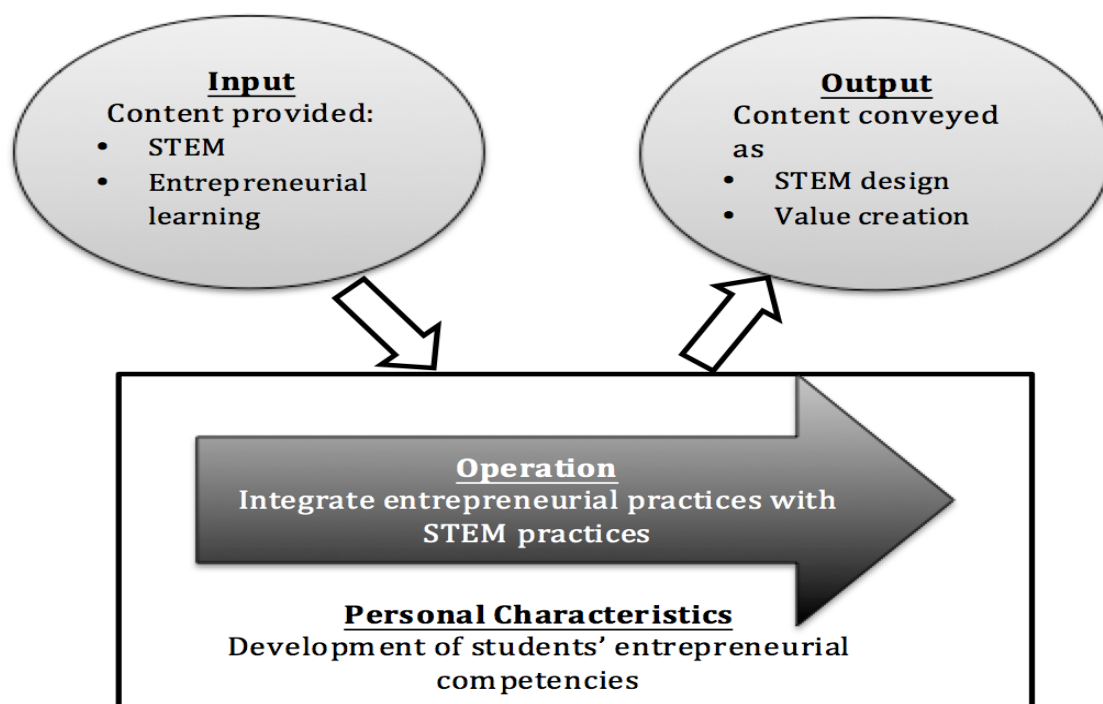


Figure 19: The Main Building Blocks of E-STEM Learning

Figure 19 illustrates the four main building blocks that help develop the desirable E-STEM model. Thus, the block of ‘input’ is represented by the content integrated from both STEM and entrepreneurial learning. Incorporating entrepreneurial practices into STEM education represents the block of ‘operation’ where a variety of cognitive activities is used to process the input. Moreover, the block of ‘output’ refers to the content conveyed to add new value and create a STEM design. Finally, the whole model targets the personal characteristic of students through the development of their entrepreneurial competencies.

In a nutshell, the current study focused on student-centred practices through interdisciplinary approach because it is characterised by innovative practices and flexibility in implementation that enhance students’ acquisition of new constructs that help them address complex situations and authentic problems (Stone et al. 2009 cited in Khadri 2014).

5.3 Outcome

Drawing on the recommendation O’Sullivan (2015) to positively communicate with teachers to impact reform changes. Despite of the lack of STEM teachers’ knowledge regarding entrepreneurial learning, the participation of business teachers in the discussion inspired them to identify the contribution of STEM programs to entrepreneurial learning. They acknowledged that STEM students in high school usually acquire many competencies such as critical thinking, problem solving, perseverance, independence, communication, collaboration and innovation that all are considered as entrepreneurial competencies, which make them more eligible to experience incorporating entrepreneurial practices into their existing STEM course than their peers who do not practice STEM. This finding is supported by Hill (2016), who targeted the entrepreneurial characteristics profile of STEM students in Higher Education and explained that STEM practices enhance students’ entrepreneurial potential.

Hence, the contribution as well as the impact of STEM education on the development of entrepreneurial learning in high school is perceived with a positive connotation. The implementation of STEM practices recognized as a catalyst for effective transformation and a prerequisite for sustainable educational reform (U.S. Department of Education 2016). In this regard, incorporating entrepreneurial practices into STEM course curricula should also gain momentum to facilitate the consistent reform required in STEM education (Bayer Corporation 2012). As a result, participating leaders and teachers emphasized that STEM learning opportunities that focus on enhancing students' STEM competencies such as planning, searching, solving problems, creativity, cooperation, critical thinking, confidence, curiosity and decisiveness through project and PBL strategies are flexible enough to accommodate entrepreneurial practices. The current study was conducted as a response to Hamad et al. (2016) who advocated the urgent need for promoting entrepreneurial learning in the UAE and proposed that schools and colleges should be partially funded by the government to encourage students in taking risks through planning entrepreneurship initiatives.

5.3.1 E-STEM Impact on Students' Learning Outcomes

In the lights of STEM leaders' perceptions, the current results revealed that competency-based practices are an effective teaching and learning approach to incorporate entrepreneurial practices into STEM education because they focus mainly on the consistent development of learning skills as well as the content knowledge. According to the literature this approach has become an increasingly popular method (Lackéus 2013) that is currently utilized for studying both entrepreneurship (Man, Lau & Chan 2002) and STEM education (Dedovets & Rodionov 2015). Contributing to this focus, adapting experiential learning pedagogy to implement E-STEM model in high school is perceived as a successful approach by the participating STEM teachers. This finding is supported by Winkler et al. (2015) who recommended applying this approach to infuse Virtual Enterprise (VE) into existing STEM courses in higher education.

Adding to that, the results of the current study came as a response to the question raised by (Ezeudu et al. 2013) regarding how can STEM courses in education go beyond the content delivery and truly support the economic growth of the country so that STEM learners can develop a broad mix of both STEM and entrepreneurship skills. A few studies demonstrated educational practices that have been proven to be successful in infusing entrepreneurial activities into STEM education (Aslam et al. 2014; Organisjana et al. 2014). Teachers believed that the consistent practices of E-STEM can affect the rate of STEM entrepreneurship in the UAE because the model focusses more heavily on students' entrepreneurial competencies through engaging STEM students in real business practices. This result is supported by the theory of trilogy of success that identified the most three interrelated factors of learning success as engagement, capacity and continuity of implementation (Compbell et al. 2004).

Further benefits of embedding STEM-based entrepreneurial practices in high school were revealed. According to the participants' perceptions, E-STEM model acts as a culturally responsive foundation for Emirati STEM students who are generally from wealthy families to enhance their entrepreneurial competencies in early stages of education with the support of their families and under the supervision of the school. Therefore, it contributes to the development of both STEM and entrepreneurial identity. This is consistent with the impact of educational practices mentioned in the literature upon students' interest, ability and competencies as it affects their future path in education and workplace as well (Heilbronner 2011). Meanwhile, E-STEM model created new opportunity of cooperation between school and home because parents were involved in the learning process side by side with the teachers to support their students' entrepreneurial tasks. This indicates that E-STEM model provided students with authentic learning opportunities through involving them in real life communications. In addition, integrated knowledge and practices help students to solve real life scenarios more successfully. This is aligned with Wurdinger (2005) who argued that

compartmentalized learning that categorized knowledge into separate disciplines does not efficiently help students to solve real-life problems. Moreover, this finding matches the STEM vision 2026 announced by the US department of education to clarify the need for inclusive learning experiences of STEM that enhance students' engagement in networked communities of practices to be able to utilize better resources, more knowledge as well as expertise required to foster the entrepreneurial mindset among learners. Adding to that, the STEM vision 2026 explained that flexible learning opportunities that diversify the locations of learning (inside and outside the school) promotes STEM pedagogies that are relevant to a particular culture (US Department of education 2016). In recognition to the diversity and flexibility of E-STEM learning opportunities in the light of the perceptions of the study participants, STEM students experienced adaptable entrepreneurial learning tasks that enhance collaboration, experimentation and creativity. Some students were able to start their small business and to gain profits, which reflects that education can close the skill gap in order to support the economy of the country by restructuring STEM education (Kelley & Knowles 2016) to accommodate entrepreneurial practices, which provides students with a new situated learning platform.

According to the current results, E-STEM model emphasizes the team-based approach and provides STEM students with accessible learning tasks that encourage intentional entrepreneurial risks through the process of discovery and investigation to tackling a real entrepreneur's challenge. As the main driver to develop and utilize the E-STEM model in high school is to equip STEM students with entrepreneurial competencies through hands-on integrated entrepreneurial and STEM practices, the findings reported from this investigation showed significant contribution to enhancing students' entrepreneurial knowledge, skills and attitude that can enrich their entrepreneurial awareness and professions contribution in supporting the economy of the UAE. Literature concerning STEM-focused education argued

that STEM learning seeks to empower more students to help build their countries as global economic leaders and financial pioneers in a time when innovation-based items and technology-based services are viewed as key to development and prosperity (Sievertsen 2016). It is also worth saying that, E-STEM model was perceived as a good step towards lunching UAE students in the direction of being entrepreneurs, especially, when most of them are from wealthy families that can support their endeavours. At the same time, this can eliminate the escalation of the unemployed population in the UAE. This result should be useful to UAE policy makers in order to guide them to utilize and consider the effect of wealth culture when designing educational policies that align the education with the labour market demands. This matches the perception of Matsumoto (2019) who reviewed the literature of UAE education reform and recommended UAE policy makers to consider the common values that can strongly impact UAE culture when defining educational reform and its success. Incorporating entrepreneurial practices into STEM education can lead to a longer-term outcome because it helps students articulate better connections between their choices of the STEM products and the market needs. Thus, this study is a promising step in generating more entrepreneurs from the STEM field.

5.3.2 Development of Students' Entrepreneurial Competencies

Teaching today's STEM students in an innovative method to become future entrepreneurs is recommended as a step forward to support the economic growth of the country (Ezeudu et al. 2013). Accordingly, the study focuses on incorporating entrepreneurial activities into STEM education. The main idea is to encourage STEM students in the high school to practice self-employment tasks by leading or engaging in business activities inside and/or outside the school in order to experience an entrepreneurial work position. Attention was mainly given to the entrepreneurial competencies that can be enhanced through this educational implementation. Thus, competency-focused pedagogical approach is originally utilized to

enhance students' outcomes through incorporating entrepreneurial practices into STEM education. In keeping with other inquiries and researches emanating from the literature of entrepreneurship education (Man, Lau & Chan 2002; Moberg et al. 2014; Rezaei-Zadeh et al., 2014; Tsakiridou & Stergiou 2014; Kydnt & Baert 2015; Dedovets & Rodionov 2015; Jamaludin & Hung 2017; Krueger & Sussan 2017; Djilali & Boucha 2018), twenty entrepreneurial competencies were selected to be relevant to form the student-competency profile mentioned in the study. The literature concerning competencies widely discussed all the possible entrepreneurial competencies whether they have an empirical support, or they are just theoretical and speculative. Moreover, it was mentioned that not all competencies are needed in all situation (Izquierdo & Deschoolmeester 2005). Thus, educational courses or programs that target the development of entrepreneurial competencies should be selective to a set of competencies that can be emphasized and developed in a certain context.

Drawing upon education through entrepreneurship in this study, non-cognitive competencies were emphasized during incorporating the entrepreneurial practices into STEM education (Moberg et al. 2014). While, STEM practices usually give more focus to cognitive innovative skills such as problem solving and critical thinking (Branes et al. 2014). In other words, this investigation breaks down what it means to be an entrepreneurial pupil into those twenty competencies that form the student-competency profile. Thus, this profile includes the basic abilities that have been conceptualized as a need for an entrepreneur to be able to start a new business.

Interestingly, the current study proved that the combination of both types of educational practices (entrepreneurial and STEM) via E-STEM model implementation was able to give adequate attention to both cognitive and non-cognitive competencies. For example, creativity, planning ability, critical thinking, decision-making, communication and adaptability are fundamental competencies in the labour market, and they are not exclusively related to

entrepreneurial education, but they are developed through STEM education as well (Elizabeth et al. 2017; Patcharee et al. 2016; Hudson et al. 2015). In this regard, the study proved that infusing entrepreneurial practices into STEM education has a double benefit effect because students, instead of developing these competencies through either STEM education or entrepreneurial practices, the integration between them expands and increases students' opportunities of acquiring the desirable skills.

Proudly speaking, not only do the results show that STEM leaders and teachers believe in the importance and possibility of incorporating entrepreneurial practices into STEM education with the collaboration of business teachers through E-STEM model implementation, but also analysing the experimental group results against the control group results found that there is a statistical significance in students' perceptions towards the development of the student-set profile that consists of twenty entrepreneurial competencies. Thus, the responses were more positive for the experimental students than the control students for the majority of measuring competencies, which means that the entrepreneurial competencies of students are affected by E-STEM practices. Thus, participating students were able to add value for others through designing useful STEM projects, which is a common core of entrepreneurship (Lackéus 2015). This result highlights the importance of incorporating entrepreneurial practices into STEM education. Furthermore, STEM students should have adequate learning opportunities that emphasize entrepreneurial learning tasks in order to produce a new generation of STEM students who are entrepreneurially literate.

Although dispositional characteristics have been theoretically analysed and listed widely in the literature for profiling an entrepreneur, the current study is taking up an expanded and empirical view of entrepreneurship by introducing its analysis of integrated practices in promoting entrepreneurial competencies of students via E-STEM implementation. The study selected the most suitable entrepreneurial competencies including knowledge, skills and

attitudes that all can be developed via incorporating entrepreneurial practices into the context of STEM education. The selected range of key competencies is from both cognitive and non-cognitive qualities that are essential for generating new entrepreneurs and was elicited from the literature based on the possibility to be enhanced and developed via integrating entrepreneurial practices into STEM education (Kyndt & Baert 2015). Competencies of entrepreneurial knowledge involve seeing business opportunity, financial awareness, product functionality, insight into the market and marketing. Competencies of entrepreneurial skills include creativity, planning ability, critical thinking, problem solving, decisiveness, persuasiveness, networkability, marshalling resources, need for achievement and analysing. Competencies of attitude include perseverance, independence, curiosity, initiative and risk-taking. Thus, the contemporary results show that the selected entrepreneurial competencies can be engendered in the high school students by applying E-STEM model through an experiential learning environment.

This result reinforces the prior study of Birdthistle et al. (2016) who found that applying entrepreneurial activities in an experiential learning environment could lead to engendering core entrepreneurial competencies into schools' youth. Additionally, Atkinson & Mayo (2010) explained that entrepreneurial practices in the U.S have been recognized as an important mechanism within STEM classes to help accelerate students' entrepreneurial behaviour.

The study found that the relationship between E-STEM practices and the three categories of entrepreneurial competencies (knowledge, skills and attitude) are measured with quite close significance values. Moreover, the comparison determined a fairly substantial correlation between the relationship between the regular treatment (STEM) and students' entrepreneurial competencies on one side in the control group, and the relationship between the new model (E-STEM) and students' competencies on the other side in the experimental group. However,

the result indicates that although applying regular STEM implementation has a good effect on the acquisition of entrepreneurial competencies, integrated E-STEM model has better effect on enhancing entrepreneurial competencies of high school students than the regular STEM implementation. In other words, E-STEM model has a greater effect on the development of students' entrepreneurial competencies, yet the regular STEM is still effective. To put these results in perspective, incorporating entrepreneurial practices into existing STEM courses is more beneficial to STEM students as it promotes the development and the acquisition of more entrepreneurial competencies.

5.3.3 Advantages of E-STEM Learning

The most highlighted advantage of the E-STEM model is that STEM students get to understand that pursuing further learning experiences is as valuable as pursuing better attainment, which generates more lifelong learners who are fully engaged in their learning. Supported by the philosophy of the social constructivist theory that emphasizes the direct interaction with others where learning knowledge is perceived as a negotiated human construct. More outcomes of the implementation of E-STEM model were highlighted as a classwork benefit; E-STEM model influenced the non-interested students in learning to be more engaged and motivated to complete their tasks especially to activities related to studying the market and to examine the functionality of the products. The enthusiastic collaboration of team members of students in the entrepreneurial-STEM practices produced valuable and creative STEM designs that are needed in the market. The cognitive perception of Vygotsky argued that all students have the potential to act creatively if they are engaged in a social constructivist learning experience (Vygotsky 1987).

The main value teachers have observed during the implementation of E-STEM experience was the reinforcement of entrepreneurial concepts as well as the exploration of entrepreneurial abilities and talent of STEM students in high school. This result is aligned with the suggestion

of Lackéus (2015) to focus on the value creation when infusing entrepreneurial practices into education to be able to identify students with positive aptitude, potential and interest to be self-employed in the future. Therefore, Lackéus et al. (2013) labelled the entrepreneurial approach a learning-by-doing value. Accordingly, E-STEM model seeks to enhance the likeliness that STEM students can be smoothly engaged in activities and practices that develop their entrepreneurial passion and mindset through promoting their entrepreneurial competencies. According to prior research findings that have been concluded that teaching and learning experiences in high school affect students' future majors and career choices (Lackeus 2015; Means et al 2018), the current study suggested that the acquisition of entrepreneurial knowledge, skills and attitude should start in the high school stage through hands-on entrepreneurial activities to motivate and prepare STEM students for the entrepreneurship education as an elective course in higher education. STEM students who designed the vendor machine were able to utilize their design in the school to add value to the school community as well as to gain profit. Ezeudu et al (2013) suggested opening a small market in each school to sell students' designs and products. According to the current successful results, it is recommended for school administration to adopt the idea of having a certain shop to support students to experience profit making in the local environment.

Chapter 6: CONCLUSION AND RECOMMENDATION

There is a constant need to enrich STEM teaching and learning to serve diverse learners and ensure that they are equipped with the competencies needed for their future careers. In the light of knowledge-based economy, one of the considerable goals of the UAE is to enhance the academic performance of students to achieve competitive levels internationally. The current research study examined incorporating entrepreneurial practices into STEM education with high school students in the UAE. Development of E-STEM model is an attempt to make meaningful association between educational experiences offered to STEM students and their lives in the UAE by giving more weight to the deep understanding of the learning concepts through a student-centred approach instead of focusing on memorizing entrepreneurial knowledge. Adding to that, E-STEM model adopts the constructivist and constructionist perspective of learning that emphasizes problem solving and critical thinking practices through making valuable designs to construct new knowledge independently.

6.1 Development of E-STEM Model

E-STEM model is an initiative that essentially aims to capture interdisciplinary teaching practices that motivate students to think entrepreneurially. The primary intent of this model is to guide STEM educators to incorporate entrepreneurial practices into their teaching methodology and to contribute to building a research agenda for both interdisciplinary STEM education and entrepreneurship education.

All the main themes elicited from stakeholders' responses were considered precisely to help develop the E-STEM model that incorporates entrepreneurial practices into STEM education. The discussion of the main findings reflected important features of E-STEM such as the main

building blocks that form the acronym of E-STEM model, essential practices to enhance E-STEM learning, elements of the strategic plan that guide E-STEM implementation, profile set of competencies that should be developed during E-STEM applications, the learning environment of E-STEM, the pedagogical approach and instructional strategies used effectively to apply E-STEM learning. All these features were utilized to describe E-STEM learning and to develop a successful model of E-STEM in education.

6.1.1 Principles of E-STEM Learning

In the light of the theoretical framework as well as the discussion of the findings, this inquiry pinpoints the main principles of Integrated E-STEM learning that identify the objectives, pedagogical approach and strategies, and outcomes of this interdisciplinary learning.

1. E-STEM learning should contribute towards cultivation of entrepreneurial STEM-literate students because entrepreneurial literacy and competencies are essential to equip learners with the basic knowledge, skills and attitudes for future careers.
2. E-STEM learning should incorporate integrated practices of the main pulleys of E-STEM acronym to make use of scientific inquiries, mathematical thinking, technological tools, engineering designs and entrepreneurial act that all support the science reform endeavour.
3. E-STEM learning involves useful STEM designs in a situated learning environment where innovation, creativity, invention and entrepreneurship values are emphasized.
4. E-STEM learning should focus on the development of the student-competency profile that contains the core entrepreneurial competencies (cognitive and non-cognitive) needed to overcome workplace challenges.

5. E-STEM learning should be implemented via interdisciplinary approach where new knowledge is embedded in integrated practices to solve real problems and add values to the society.
6. E-STEM learning should engage students in real business practices through enhancing entrepreneurial literacy to provide new solutions, construct new knowledge, and offer new values to the local community.

6.1.2 Main Pulleys of Interdisciplinary E-STEM Learning

The current study connected the main pulleys that present the integrated practices of scientific inquiry, technological literacy, mathematical thinking and engineering design to a new pulley of entrepreneurial act, to develop a new pulley system of integrated E-STEM learning. In this regard, the available joint potential of STEM disciplines is utilized to make learners think, perceive and behave in a more entrepreneurial manner. Thus, the implementation of interdisciplinary E-STEM practices is highlighted to examine its impact on the entrepreneurial core competencies of the students. The following figure illustrates the new pulley system of the interdisciplinary E-STEM learning after integrating the Kelley and Knowles's STEM pulley system with entrepreneurial practices

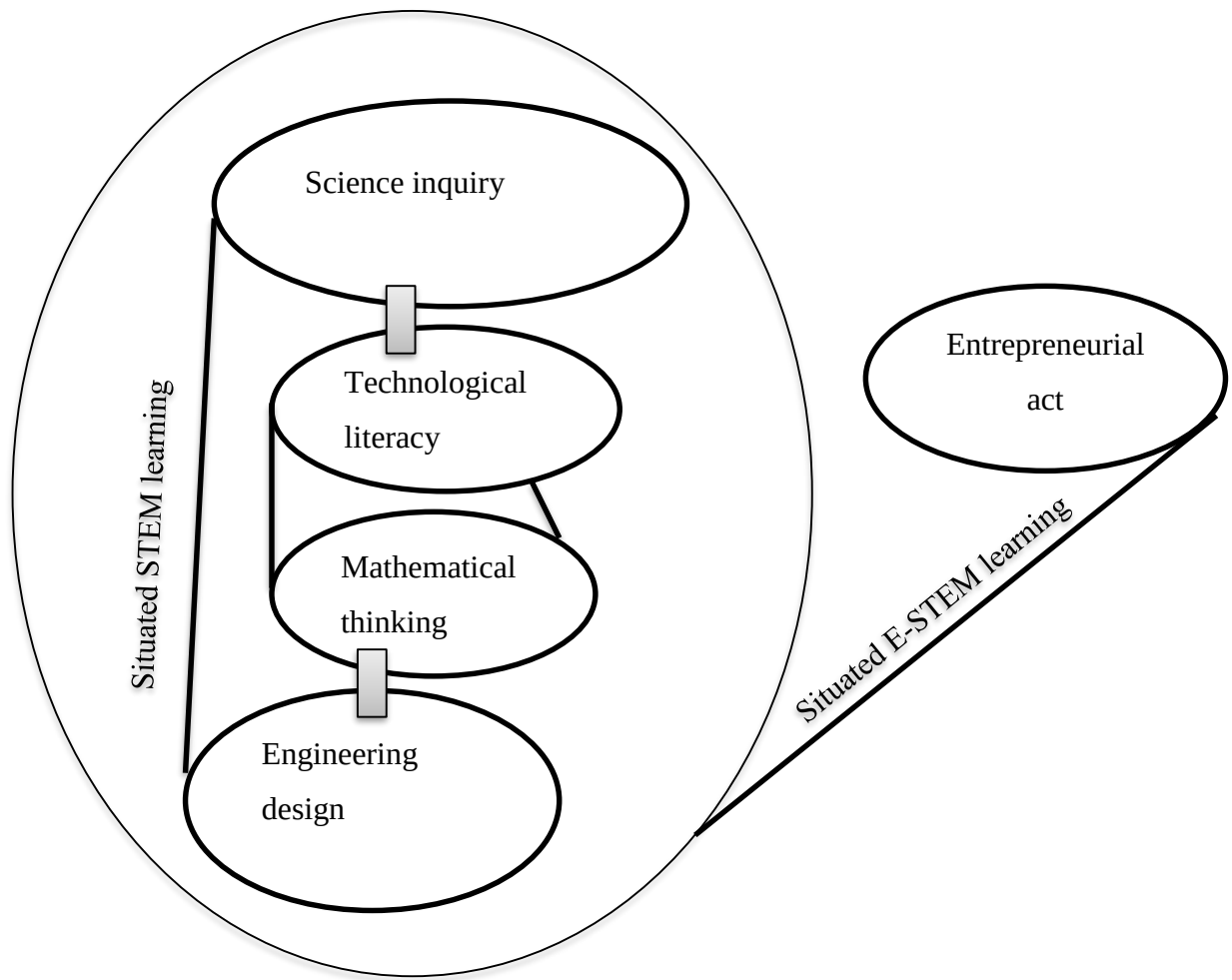


Figure 20: The main pulleys of the Interdisciplinary E-STEM Learning

Figure 20 illustrates the pulley system that shapes the building blocks of the interdisciplinary E-STEM learning, where entrepreneurial practices are incorporated into the integrated pulleys of STEM disciplines in a situated learning environment. The following section explains the activities conducted in the pre-implementation stage of the E-STEM model, the activities conducted during the implementation, and finally the E-STEM projects achieved as a result and outcome of E-STEM implementation in the high school.

6.1.3 Framework of the E-STEM Learning

The following figure demonstrates how knowledge of the E-STEM disciplines is integrated to implement educational practices through competency-based approach. Experiential learning in general, project-based problem solving is the main pedagogical strategy used to enhance entrepreneurial competencies of STEM students including knowledge, skills and entrepreneurial attitude, that is an attempt to influence producing more STEM entrepreneurs.

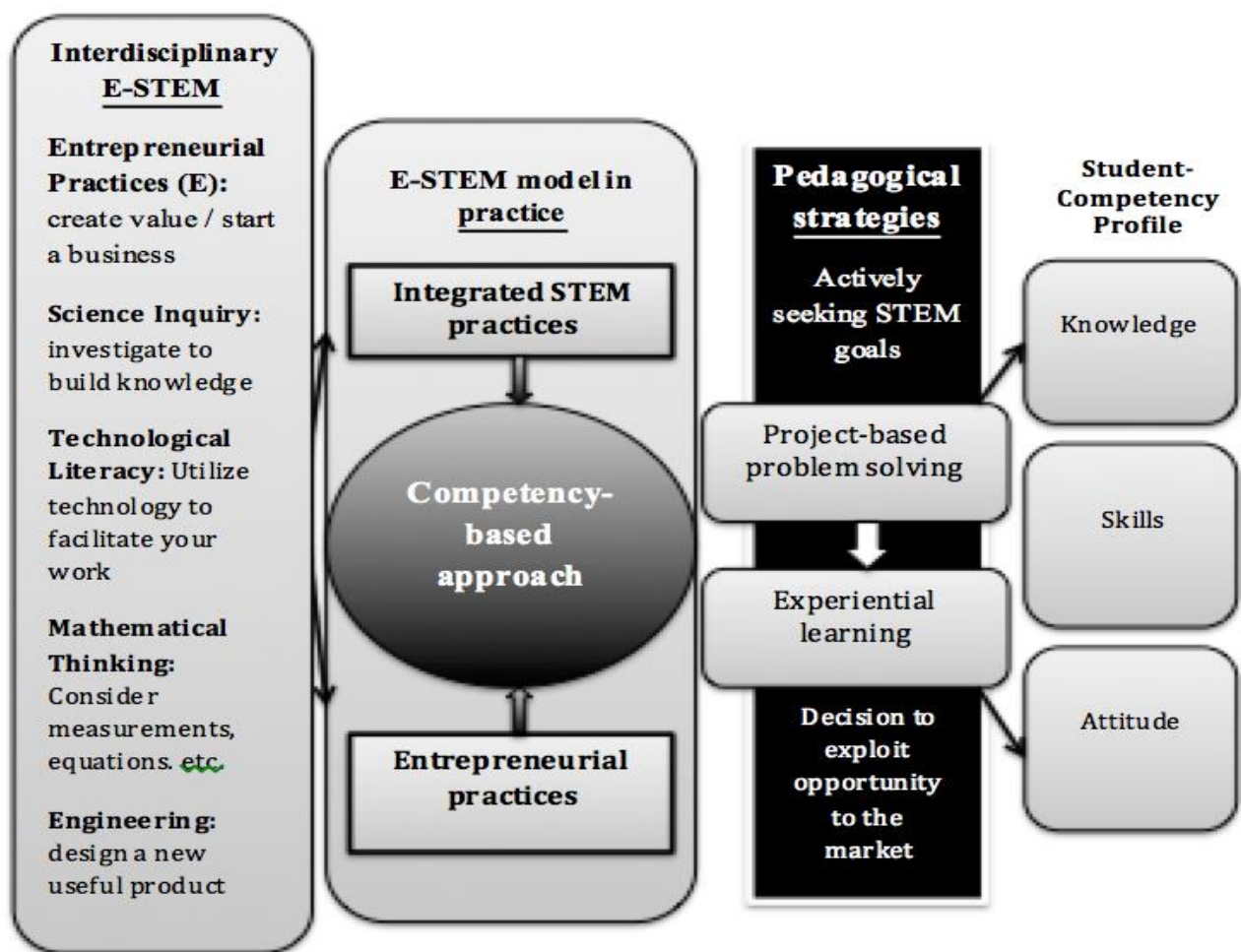


Figure 21: The Framework of the Implemented E-STEM Model

Figure 21 demonstrates the framework designed for E-STEM after six months implementation of this educational model with high school students. The framework identifies the pulleys of

each subject in the interdisciplinary E-STEM (scientific inquiry, technological tools, engineering design, mathematical thinking, and entrepreneurial act), the learning approach used to incorporate entrepreneurial practices into integrated STEM education is competency-based approach that focuses more heavily on practices that target students' competencies' profile of entrepreneurship, and the pedagogical strategies derived from experiential learning such as project-based problem solving to enhance students' entrepreneurial knowledge, skills and attitude.

6.1.4 Pre-Implementation Stage of E-STEM

The implementation of E-STEM model focuses more consistently on developing twenty entrepreneurial competencies that form the student-competency profile and all are mentioned in the literature review section. Thus, the data collected from the exploratory stage was used to design a clear strategic plan in order to guide the participating teachers during the implementation of E-STEM model. This plan included certain activities that allow students to be ready to work on an E-STEM project in order to add value to society. The following figure shows the strategic plan of the intended E-STEM model.

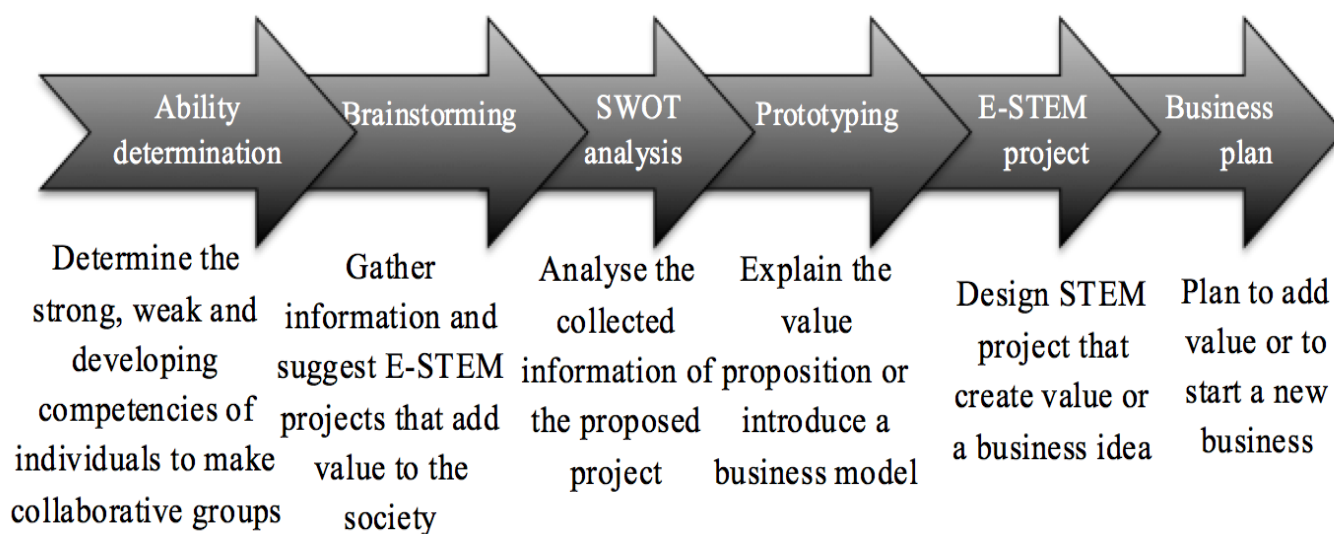


Figure 22: Strategic Plan of the Intended E-STEM Model

Figure 22 demonstrates the main six activities that form the intended E-STEM model that allow students to experience entrepreneurial learning in their STEM classes in the light of education-through entrepreneurship which is highly recommended to their age group (Lackeus 2015).

- **Ability determination of each student:** The student- competency profile should be introduced to STEM students in order to determine their strengths and weaknesses, as well as competencies that they are working on developing.

Table 33: The Form of the Ability Determination of Individuals

Student- Competency Profile			
Cognitive entrepreneurial competencies		Non-Cognitive entrepreneurial competencies	
Knowledge	Skills		Attitude
Seeing opportunities Financial awareness Product Functionality Insight into the market Marketing	Creativity Planning ability Critical Thinking Problem Solving Decisiveness	Persuasiveness, Networkability Marshalling resources Need For success Analysing	Perseverance Self-confidence Self-knowledge, Initiative (pro-activity) Risk-taking
- Use the competencies listed above in the students-competency profile to determine your strengths and weaknesses as well as the competencies that you are working on its development.			
Ability determination of each student			
Strong Competencies	Weak	Developing Competencies	

Table 33 represents the form of the ability determination of participating students where they were asked to self-assess their abilities to complete the given form.

- **Making collaborative groups:** according to the strengths and weaknesses determined by each student, collaborative groups of students should be formed to work on the E-STEM model.

- **Brainstorming:** each group gives some ideas of E-STEM projects that they suggest for implementation. At this step, students should discuss the need and the value of each idea in order to select the best E-STEM project for implementation.
- **SWOT analysis:** It is a tool used by each group of students to analyse the information of the proposed E-STEM project to clarify the strengths, weaknesses, opportunities and threats that they are expecting to face during the implementation. Furthermore, students will identify the available as well as the necessary resources to achieve the project.

Table 34: The Form of SWOT Analysis of the Proposed E-STEM Project

Information Analysis of the proposed E-STEM Project			
Strengths (S)	Weaknesses (W)	Opportunities (O)	Threats (T)
Resources: (Funding, equipment, products, training...etc.)			
Resources Available		Resources Needed	

Table 34 represents the form used to employ the SWOT analysis of the proposed E-STEM project of each group of participating students.

- **Prototyping:** school conference or class presentations should be designed to give students the opportunities to convince the surrounding community the need for their E-STEM project as well as create interest before actual implementation. Thus, during the presentation, students focus on the value proposition or introduce a business model that can serve the target audience. In addition, surveys should be conducted to clarify whether people accept and encourage their ideas.

6.1.5 Situated Platforms of E-STEM Model

- **E-STEM Project:** Instead of placing an emphasis in only teaching the content or developing the skills needed for the workplace in a different setting, then hoping the students will realize the connections to real-life situations., the interdisciplinary approach used to implement the integrated E-STEM model seeks not only to locate applicable connections between E-STEM disciplines but also provide a relevant context for the learning experiences. Students should understand the value and the need of their proposed design as well as the target audience that will gain benefits from this service.
- **Business Plan:** The business plan is designed to help STEM students work more deeply on the cognitive competencies that emphasize the entrepreneurial knowledge, such as product functionality, insight into the market, marketing and financial awareness.

Table 35: Business Plan Form

E-STEM idea	
What is your E-STEM idea? What is its name?	
What makes your idea different?	
What does this name say about your project/business? Is it unique? Memorable? Easy to pronounce?	
Product Functionality	
How will your product/service stand out from the competition? What is its function?	
Why will people want your idea? Is it needed?	
Insight into the market	
Top competitor(s):	Equivalent product/service:
Target Market & Demographics	
Who are your target audience? Who are your customers? Ex. Kids, teenagers, men, women...etc.	
What is your target market passionate about?	
Marketing	

How will you get the word out about your service/ business? Networking? Online (website, social media)? Posters? Newspapers? Email?			
Where will you make your service or sell your product? Finding customers?			
Financial Awareness			
Pricing		Profit	
How much will you charge?	Sale price of item:	Cost of item:	Profit:
What is your competitors' charging? (If applicable)	How much will you make on each sale? (Profit=income-expenses)		
What will you do with the money you make? Reinvest in a business? Save for college? Donate?			

Table 34 represents the form of the business plan used to allow students to learn and apply more entrepreneurial knowledge regarding their E-STEM project. Students were asked to answer all the given questions in the plan that focus on their idea, functionality of the STEM design, and marketing and financial awareness.

6.2 Conclusion

The paradigm shift in the contents and instructions of both STEM education and entrepreneurship education in schools has continued to create challenges to educators. In recent times the gradual obligatory and academic demands to connect learning objectives to real life applications and career requirements has been perceived as addition to teaching and learning rigors. Therefore, the current study aimed to develop a new educational model (E-STEM) to guide STEM teachers to be able to incorporate entrepreneurial practices into existing STEM course. The results of both the first questionnaire and the interviews in the exploratory stage discovered that academic leaders and teachers of STEM presented positive perceptions toward infusing entrepreneurial practices into STEM disciplines. Hence, enhancing the entrepreneurial competencies of STEM students through incorporating entrepreneurial practices into STEM education via applying experiential learning strategies is emphasized in the study through providing new evidence from integrated instruction in order

to promote students' knowledge, skills and attitude of entrepreneurial learning. The study argued that although STEM education can positively contribute and impact the entrepreneurial learning, teaching STEM courses or programs without incorporating entrepreneurial practices into STEM is not enough to produce entrepreneurs. STEM students should be nurtured more effectively by providing them with authentic entrepreneurial learning opportunities to become the future scientific and technological entrepreneurs. The interdisciplinary nature of both STEM and entrepreneurship education facilitates the integration between their practices to motivate students to behave more entrepreneurially. Therefore, the main goal of developing the E-STEM model is not to have a prescribed set of educational practices, however, it aims to motivate action towards STEM reform through providing a strong evidence for what STEM learning opportunities work best in the UAE context. Generally, the study intends to provide E-STEM model as an initiative to improve matching the supply of competencies with demand for entrepreneurial STEM labour, which in turn could enhance the competitiveness of the labour market. Sufficient STEM student supply equipped with entrepreneurial competencies is essential to support the goals of UAE national Agenda.

The findings of the second questionnaire and interviews in the confirmatory stage revealed that the implementation of E-STEM practices positively related to students' entrepreneurial competencies. Moreover, the interdisciplinary practices of E-STEM model guide STEM teachers to be able to effectively incorporate entrepreneurial practices into the existing STEM course. It is vital that UAE learners are equipped with the essential learning basics and are consistently exposed in the school stage to a wide range of entrepreneurial competencies before heading to higher education or venturing into the workplace. Jones & Iredale (2010) argued that educating students to become entrepreneurs is different from educating them to act entrepreneurially. The current study illustrated that restructuring STEM education to accommodate entrepreneurial practices expands the range of learning tasks and experiences

made available for STEM learners. E-STEM practices do not focus only on designing engineering products but also on expanding the impact of these products on the community through marketing. Hence, the learning activities of E-STEM model enhanced the potential of STEM students in the UAE to act entrepreneurially. Students' efforts need to be supported through establishing new programs and funding initiatives to employ their untapped potential. Integrated practices through the implementation of E-STEM model can support the development of STEM learners toward being the future scientific entrepreneurs. In order to prepare the next generation of Emirati students to be able to compete effectively in the STEM workplace, UAE education must instil both proficiency and interest in entrepreneurial STEM practices at a young age. The results of the current study found that STEM education that focuses on enhancing students' STEM competencies such as planning, searching, solving problems, creativity, cooperation, critical thinking, confidence, curiosity and decisiveness through project and problem-based learning strategies is flexible enough to be restructured to accommodate entrepreneurial practices. This is in order to expand the development of students' entrepreneurial competencies such as value creation, seeing business opportunities, financial awareness that all are not emphasized in the current STEM curriculum applied in the UAE. Therefore, E-STEM model acts as a guidance for curriculum planners to be able to initiate a seamless sequence of a new E-STEM course that provide high school students with meaningful entrepreneurial learning opportunities to allow them to communicate more successfully with their community. All these results reflect that restructuring STEM education to incorporate entrepreneurial practices would help address difficulties inherent in generating learners for a complex workplace where blurred boundaries of disciplines are the prevalent challenge.

Hence, UAE schools should continually learn to improve their implementation of STEM best practices. It is concluded that the intervention of E-STEM model can impact STEM students'

preparedness and readiness to act as effective contributors in achieving the UAE vision of 2030 that aims to support and expand UAE future economy. UAE students need to be educated about entrepreneurial practices and develop the mindset that promote their entrepreneurial behaviour, and teachers need to provide STEM students with more flexible and inclusive learning opportunities that help engage them in the community practices through utilizing all the available learning resources as well as experts' support. Therefore, E-STEM model provides insights for facilitating opportunities of self-employment learning within integrating curricula to help prepare students for a world, which believes that the acquisition of variety of competencies takes precedence over the accumulation of content knowledge.

In a nutshell, the main following contributions of the study came as a result of the constructivist grounded theory conducted in the UAE context and tested in the confirmatory stage:

1. Proposing E-STEM model that incorporates entrepreneurial practices into STEM education with consideration to the characteristics of the UAE context.
2. Developing integrated teaching and learning practices where a conceptual framework of E-STEM instruction is demonstrated to incorporate business with STEM disciplines.
3. Generating a conceptual framework of E-STEM that consider the contextual factors such as, existing STEM curriculum, learning environment, instructional strategies, technology integration, business applications.
4. Evaluating the E-STEM model that reflects the positive relationship between E-STEM practices and students' entrepreneurial competencies based on the perception of the participating students from high school in the UAE.
5. Identifying the profile set of competencies of the student that includes 20 entrepreneurial competencies that are meant to be developed through the implementation of E-STEM model.

6. Providing new training materials to educators to help prepare STEM teachers to better deliver integrated curriculum.
7. Identifying the main principles of integrated E-STEM learning that focuses on acting entrepreneurially through integrating two or more of STEM disciplines to establish new values.

6.3 Implication

The results of the current study explained that incorporating entrepreneurial practices into STEM education is possible to be done in the UAE and desirable from STEM leaders and teachers as well. This section highlights both the practical implications that are useful for both teachers and high school students, and the professional implications that target future reform conducted in education by policy makers and curriculum developers.

6.3.1 Practical Implications

E-STEM model proved that entrepreneurial learning could be integrated and taught to UAE young learners through applying a well-structured instruction that provides students with ill-structured problems to enhance their entrepreneurial skills. This finding creates room to incorporate business as situated E-STEM learning experience within the project-based paradigm that enhances the alignment between STEM disciplines and entrepreneurial practices.

High School Teachers

Teachers are the actual practitioners and they are responsible for delivering the curriculum to students. Thus, the E-STEM model introduces one possible method to guide teachers to understand how entrepreneurial practices can empower STEM learners in high school to develop useful STEM designs and to apply positive entrepreneurial habits through the acquisition of entrepreneurial competencies. Consequently, the main elements of E-STEM

model could serve as the foundation for a rubric to assess and improve the quality of E-STEM implementation in UAE schools. Additionally, the rubric designed in the light of E-STEM elements could help address the challenge mentioned by the stakeholders that it is difficult for teachers to assess E-STEM outcomes. Accordingly, E-STEM model contributed effectively by providing new curriculum elements, integrated practices and assessment rubric that are aligned successfully to guide teachers' instructions. Therefore, findings of the study provide new training materials to educators in schools to be able to offer E-STEM learning opportunities to high school students. This implementation will reduce the risk of loss of students' innovative designs that are usually kept in the stores of schools. In this essence, E-STEM model provides benefits for stakeholders in STEM education who aim to 1) define instruction strategies to bridge the skill gap between STEM objectives and market needs, 2) identify the main pulleys required to successfully incorporate entrepreneurial practices into STEM courses, 3) determine strategic plans and opportunities to implement E-STEM in high school, 4) investigate E-STEM challenges and plan to address them, and 5) discover students' entrepreneurial talent and suggest programs to nurture them. As a result, STEM education is likely to improve and change towards supporting education reform. Adopting and emphasizing a single change in in one dimension of STEM education to accommodate business objectives in its environment can have large-scale effect in the future.

High School Students

Incorporating entrepreneurial practices into STEM education to enhance students' entrepreneurial competencies should be highlighted in the UAE National Agenda because it is desirable to UAE STEM students who originally coming from wealth families as well as beneficial to their personal development. Thus, they can impact the national economy of the country in the long term. Students became more interested in STEM learning through this incorporation that motivated them to emphasize and test the value of their STEM designs in

order to make sure that they can add benefits to their community. Applying E-STEM model was a successful learning opportunity because it allows students to acquire new resources through discovering and building multi-level learning channels. The effective collaboration between school, home and the market allows students to consistently communicate with teachers, parents, and available experts to expand their network in order to achieve their entrepreneurial learning goals. More importantly, learning becomes more visible to students because they were able to pose their own questions, identify their goals, determine their abilities and areas of development, value everyone's skills and collaborate to make use of all resources, realize that failure is a learning chance that should be utilized, get involved in the market, consider simple financial situations, become more familiar with taking risks because ultimately, that is what entrepreneurship is all about.

6.3.2 Professional Implications

Since, PjBL and PBL strategies are recommended for both types of education in the light of a competency-based approach. E-STEM model assumes that interdisciplinary work during integrating entrepreneurial practices with STEM learning programs can lead to new curricular components. Therefore, it can be used to create new unified E-STEM curriculum in high school that address the needs of UAE students and consider the characteristics of their culture.

Curriculum Developer

The discussion of the current study highlighted the opportunities of incorporating entrepreneurial practices into STEM education as well as the challenges of this incorporation, which opens up new avenues for both UAE curriculum developers to benefit from the results achieved from the available researches conducted in the UAE context to support the education reform. Incorporating entrepreneurial practices into STEM education require high level of integration between practices of project-based problem solving and value creation where

students should focus on a clear strategic plan designed to emphasize E-STEM features that include planning, searching, collecting data, designing, studying the market and add specific value to the society. New curriculum mapping could be created to align E-STEM course requirements, instruction and assessment practices to guide high schools teachers for effective implementation.

Researchers

Accordingly, the findings provided a new agenda of both opportunities and challenges that UAE schools face in aligning the E-STEM model with their existing educational system. Thus, the contextual factors that were considered in the current inquiry to generate the E-STEM framework such as learning environment, instruction, existing STEM course and curriculum implemented should be investigated to explain the extent to which these factors can influence the impact of the E-STEM model on entrepreneurial learning. The implication of affording better STEM education with entrepreneurial opportunities to STEM students is considerate for a society like the UAE that aims to regain and expand its economic resources to be knowledge-based among other competitive and developed countries. Necessary policy responses should be discussed consistently to facilitate the implementation of integrated curriculum such as E-STEM and to offer solutions that address issues like resources limitation, capacity of teachers to apply new applications and other regulatory obstacles as well. Furthermore, the implementation of E-STEM model could enhance the policy extension of Science, Technology, Innovation Policy (STIP) that is emphasized in the UAE to enhance the economic situation of the country.

Policy Makers

According to this discussion, it is time for UAE policymakers to establish their own original policies according to discourses and investigations such as this inquiry that was specifically

tailored and conducted to the culture and stakeholders of the UAE rather than reliance on policy borrowing from other countries. It is always appropriate to look back at how far practitioners and policy makers have come in the development of any process under discussion in order to realize the extent to which they have progressed with an eye to what remains to be done and where specific context seems to be heading. Developing a contextual model for Emirati students who study STEM to enhance their entrepreneurial competencies and contribute to their cultural values by enriching their personal interests is a good project that should be investigated, implemented and re-evaluated.

6.4 Recommendation

E-STEM model was developed to provide evidence-based recommendations to guide STEM educators, curriculum developers as well as policy makers to update the curricula disciplines of STEM education. The use of E-STEM model as a well-structured instruction with its integrated practices in an interdisciplinary learning environment has led to a new research agenda. Further studies are needed to investigate the efficiency of adapting the E-STEM model through experiential learning pedagogy in different educational stages. The feasibility of adopting E-STEM model among high schools in the UAE should be also studied to examine the options of developing and upgrading a unified E-STEM curriculum that supports incorporating entrepreneurial practices into STEM education based on students' needs. More opportunities for E-STEM-focused programming that include integration between entrepreneurial activities and STEM practices should exist. Moreover, a further comparison of entrepreneurial competencies development for Emirati high school students with their equivalents in regional and international contexts is suggested. It will be beneficial to re-test the E-STEM model through observing the actual implementation of the integrated practices in the classroom in order to identify the strengths and gaps from a different perspective. To establish a platform for students to produce STEM designs-based entrepreneurial learning that

focus on identifying social challenges or dilemmas and think critically through entrepreneurial approaches to solve such problems. In recognition of the challenges of incorporating entrepreneurial practices into STEM education, E-STEM model designed and examined in this study is meant to be a starting point upon which the main stakeholders, including teachers, leaders, educators, researchers and policy makers can build. In this essence, the study suggests that reform based-educational policies should be emphasized to enhance the integrated knowledge and practices required to produce better STEM instruction to learners in high school and prepare them for the workplace challenges. Another focused research question should be investigated: Does implementing E-STEM model increase the likelihood that a student will become an entrepreneur in STEM fields?

It is highly recommended to examine the extent to which school administrations are willing to offer solutions to the challenges raised in the study to better support the E-STEM implementation rather than just giving advice to teachers. Moreover, the professional development program of teachers should be emphasized consistently to help them master integrating practices from different disciplines more effectively. Thus, the effect of these programs on the efficiency of E-STEM model and its outcomes should be investigated. Furthermore, it is useful to examine the effect of E-STEM model on students' attainment in the Cognitive Ability Test (CAT4) that identify their learning styles and preferences. The study also advises high school administrations of the UAE to adopt the idea of establishing a school market in order to give students authentic learning opportunities to experience being entrepreneurs. On the other side, teachers can utilize the school market to implement more integrated entrepreneurial activities with different disciplines.

6.5 Limitation

The current study has some limitations that may constitute new avenues for further inquiries. The major limitation of this research inquiry results from the inability to recruit more students

in high school to implement E-STEM model due to the limited access imposed by the school administration. Second, only one Emirate participated in the confirmatory stage to implement the E-STEM model to examine its impact on students' outcomes. Another limitation is related to the support provided by the school administration to the path of the data collection needed as lots of restrictions were followed during the study, which consumed more time and effort.

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APPENDICES

Appendix (1)

School Consent Form



November 2017

To Whom it May Concern,

I am a doctorate student in the British University in Dubai since 2016. I am conducting a research study about incorporating entrepreneurial practices into STEM education to enhance students' entrepreneurial competencies. The study will develop an entrepreneurial-STEM model (E-STEM) to be implemented for the local use in the educational field.

The purpose of this letter is to take permission from your school(s) to conduct my study in your educational organization in the academic years 2017/2019. This study requires an interview setting with head of STEM teachers and educational leaders as well, questionnaire for STEM teachers, implementation of E-STEM model, interview with STEM teachers and questionnaire for STEM students.

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

Best Regards

Marwa Eftanahy

Academic researcher

Mobile: 0501493497

Email: marwatanahy@gmail.com

Professor Sufian Forawi

Faculty of Education

Tel: +971 4 279 1439

Email: sufian.forawi@buid.ac.ae



Appendix (2)

Consent Form for STEM Academic Leaders

Dears,

I am a graduate student in the British University in Dubai BUID. I am doing a research about *“Development of Entrepreneurial Core Competencies: Implementation of E-STEM Model for High School Students in the UAE”*. I am conducting a research study to (1) to explore academic leaders’ beliefs about incorporating entrepreneurial practices into STEM education, (2) to explain the effective entrepreneurial practices within STEM classes that enhance incorporating entrepreneurial practices into STEM education as well as the challenges of successful incorporation, (3) to develop a model of an entrepreneurial-STEM education based on participating teachers’ and leaders’ perceptions (E-STEM), (4) to explore participating E-STEM teachers’ beliefs regarding the impact of implementing E-STEM model on students’ learning outcomes and (5) to examine the relationship between E-STEM practices and students’ entrepreneurial competencies. High school students (grades 10-12) and participating STEM teachers will know that they are being asked for their input about their perceptions and practices of the acceptance in participating in this study.

The participation in this face-to-face interview for academic leaders will involve answering questions relating to your demographic background and questions related to your perceptions and practices in incorporating entrepreneurial practices into STEM education. Moreover, STEM teachers will be asked to respond to a questionnaire that seeks to investigate their perceptions regarding the possibility of incorporating entrepreneurial practices into STEM education as well as challenges that may eliminate this incorporation in UAE. Your participation in this study is voluntary. If you choose not to participate or withdraw from the study at any time, there will be no penalty. The information collected from this interview is anonymous and confidential.

Thank you for being part of this research. I truly appreciate your time and effort in answering the interview questions for my research. If you have any questions concerning this research study, please contact me on the following email: marwatanahy@gmail.com.

Sincerely,

Marwa Eltanahy

Appendix (3)

Educational Leaders' Interview

- **Interview Protocol Project: The British University in Dubai (BUID):**

Date:	Place:
Interviewer: Marwa Eltanahy	Interviewee:
Position of interviewee:	How many years in the school:

- **Brief description of the project;**

The significance of this study is to make use of insights from theories of both STEM education and entrepreneurship education into individuals' success. While its purpose is to produce an

- **Questions:**

1. What do you know about entrepreneurial learning?
2. What is the contribution of STEM education to entrepreneurial learning?
3. Can entrepreneurial learning be incorporating into STEM education? How?
4. Does STEM program used in your organization support the development of students' entrepreneurial competencies? How?
5. What are the main barriers that eliminate the integration of entrepreneurship in STEM education?

Appendix (4)

STEM Teachers' Questionnaire

This questionnaire is going to ask STEM teachers about their perceptions in relation to the best practices that can enhance students' entrepreneurial competencies and the barriers of integrating entrepreneurial practices into STEM education.

Please read the following definitions before completing the questions

Entrepreneurship education: an education that teaches students how to start up new business through teaching and learning practices that enhance their competencies

There are no correct or incorrect answers and all responses will be kept confidential

Section 1; STEM Teachers' Demographic Information.

Gender	Male ()		Female ()	
Teaching experience	1-4 years ()	5-10 years ()	More than 10 years ()	
Academic qualification	Bachelor ()	Diploma ()	Master ()	
Emirate		Subject Taught		

- Please, mark the choice that matches your perception. Use the following rating scale assigned for each group of questions

Section 2: Effective Practices of STEM than Enhance Entrepreneurial Learning

A. Current Practices applied to enhance entrepreneurial learning

- **How much emphasis do you encourage your students to apply the following practices in your STEM classroom to promote entrepreneurial learning?**

5= Always applied	4= Often applied	3= Occasionally applied	2= Rarely applied	1= Never applied
Current Practices Applied in the STEM classes				5 4 3 2 1
Problem-based Learning/ Project-based Learning				

Students integrate information from STEM disciplines to design new products					
Students take responsibility of their own learning					
Students identify the problem and pose questions					
Students plan for their inquiry					
Students apply technology strategically					
Students are engaged in logical reasoning to solve the problem					
Students evaluate their projects through a design rubric					
Students reflect on their learning and modify their plans					
Students cooperate and collaborate in a STEM team					
Students use teachers' and experts' feedback to improve their products					
Students discuss, argue and present their projects to the classmates					
Value Creation & Business-startup					
Students use their STEM outcomes/designs to create or add value to the society					
Students study the market to know if their products are needed					
Students calculate the costs required for their projects					

B. Suggested Practices in STEM Pedagogy to Facilitate Entrepreneurial Learning

- **What are the most appropriate practices that should be added to STEM course pedagogy in order to support students' entrepreneurial learning?**

5= Strongly agree	4= Agree	3= Neither agree nor disagree	2= Disagree	1= Strongly disagree
Suggested practices to enhance entrepreneurial learning				
5	4	3	2	1
Guest speaker: invitation of entrepreneurs to speak about their successful experiences in the market				
Lectures to explain useful case studies				
Hands on experience business startup: each group of students makes a simple business to sell their products.				
Company visits: regular trips to communicate with the real market				
Computer simulation				
Attend summer school programs to achieve business tasks				
Supplementing entrepreneurial learning with extracurricular activities				
Establish a new department for entrepreneurship programs to incorporate entrepreneurial learning into courses where business teachers are involved				

Section 3: Challenges of implementing entrepreneurial practices in STEM education

- What are the main challenges that prevent applying entrepreneurial practices in STEM education?

5= Strongly agree	4= Agree	3= Neither agree nor disagree	2= Disagree	1= Strongly disagree
Obstacles of incorporating entrepreneurial practices into STEM				
5	4	3	2	1
Lack of teachers' knowledge about entrepreneurial practices				
Lack of materials, resources and funding				
Time limitation				
Entrepreneurial practices do not meet my students' interest				
Entrepreneurial practices do not fit in the STEM curriculum used				
Entrepreneurial practices are difficult to be assessed				
Lack of innovative products: students' projects are regular and not required in the market				
Lack of administrative support				

Section 4: Answer the following questions:

- What are your most STEM practices that can enhance students' entrepreneurial skills? Explain
- Can you suggest ways to help enhance students' entrepreneurial identity in STEM education?

Appendix (5)

Consent Form for E-STEM Teachers

Dear Sir/Ms:

I am a graduate student in the British University in Dubai BUID. I am doing a research about “*Development of Entrepreneurial Core Competencies: Implementation of E-STEM Model for High School Students in the UAE*”. I am conducting a research study to (1) to explore academic leaders’ beliefs about incorporating entrepreneurial practices into STEM education, (2) to explain the effective entrepreneurial practices within STEM classes that enhance incorporating entrepreneurial practices into STEM education as well as the challenges of successful incorporation, (3) to develop a model of an entrepreneurial-STEM education based on participating teachers’ and leaders’ perceptions (E-STEM), (4) to explore participating E-STEM teachers’ beliefs regarding the impact of implementing E-STEM model on students’ learning outcomes and (5) to examine the relationship between E-STEM practices and students’ entrepreneurial competencies. High school students (grades 10-12) and participating STEM teachers will know that they are being asked for their input about their perceptions and practices of the acceptance in participating in this study.

You will be asked to participate in implementing the E-STEM model in your classes that requires applying the regular STEM practices of your school as well as incorporating entrepreneurial practices (business activates) into the existing STEM course.

After E-STEM implementation, you will be asked to participate in a face-to-face interview for participating E-STEM teachers that will involve answering questions relating to your demographic background and questions related to your beliefs regarding the impact of incorporating entrepreneurial practices into STEM education on students’ learning outcomes.

Your participation in this study is voluntary. If you choose not to participate or withdraw from the study at any time, there will be no penalty. The information collected from this interview is anonymous and confidential.

Thank you for being part of this research. I truly appreciate your time and effort in answering the interview questions for my research. If you have any questions concerning this research study, please contact me on the following email: marwatanahy@gmail.com.

Sincerely,

Marwa Eltanahy

Appendix (6)

E-STEM Teachers' Interview Protocol

- **Interview Protocol Project: The British University in Dubai (BUID):**

Date:	Place:
Interviewer: Marwa Eltanahy	Interviewee:
Position of interviewee:	How many years in the school?

- **Brief description of the project;**

The significance of this study is to make use of insights from theories of both STEM education and entrepreneurship education into individuals' success, while its purpose is to produce an applicable E-STEM model that guides teachers to incorporate entrepreneurial practices into STEM education in order to enhance students' entrepreneurial competencies.

- **Questions:**

1. What is the impact of the implementation of entrepreneurial STEM model (E-STEM) on the students' learning outcomes?
2. Do you believe that the new E-STEM model is a step forward in the UAE's educational reform and a step towards better STEM implementation? Explain.
3. What are the main advantages you have observed of the entrepreneurial-STEM model on your students?
4. What are the difficulties you have faced during applying the E-STEM model? Did you overcome any of them?
5. Are you willing to implement E-STEM model again in your class? Why?

Appendix (7)

Consent Form for High School Students

Dear Sir/Ms.,

I am a graduate student in the British University in Dubai BUID. I am doing a research about “*Development of Entrepreneurial Core Competencies: Implementation of E-STEM Model for High School Students in the UAE*”. I am conducting a research study to examine the impact of implementing E-STEM model on students’ learning outcomes. This model incorporates entrepreneurial practices into STEM education. As a high school student (grades 10 and 11), you are kindly asked for your input about your perceptions and practices of the acceptance in participating in this study.

You will be asked to participate in implementing the E-STEM model that requires applying the regular STEM practices of your school as well as incorporating entrepreneurial practices (business activates) into the existing STEM course.

Moreover, this questionnaire will be conducted twice: in the beginning of this academic year 2018/2019 and then will be conducted again after implementing the E-STEM project that might take two academic terms. The participation in this survey will involve answering questions relating to your demographic background and questions related to your perceptions and practices in the E-STEM model that incorporate entrepreneurial practices into STEM education.

Your participation in this study is voluntary. If you choose not to participate or withdraw from the study at any time, there will be no penalty. The information collected from this survey is anonymous and confidential.

Thank you for being part of this research. I truly appreciate your time and effort in answering the questionnaire for my research. If you have any questions concerning this research study, please contact me on the following email: marwatanahy@gmail.com.

Sincerely,

Marwa Eltanahy

Appendix (8)

E-STEM Students' Questionnaire

This questionnaire is going to ask students about their perceptions of STEM practices that enhance entrepreneurial competencies

There are no correct or incorrect answers and all responses will be kept confidential

Please read the following definitions before completing the questions

Entrepreneurial Learning: education that promotes students' awareness about the self-employment as a career option or adding values to the society by equipping them with the basic skills, knowledge and experience required for starting up a new business.

Section 1; Students' Demographic Information.

Gender	Male ()	Female ()
Grade		

- Please, mark the choice that matches your perception. Use the following rating scale assigned for each group of questions

Section 2: Practices of E- STEM Model

- **How much emphasis do you place on the following practices in applying E-STEM model?**

5= Always applied	4= Often applied	3= Occasionally applied	2= Rarely applied	1= Never applied				
Main interdisciplinary E-STEM Practices				5	4	3	2	1
I interpret and communicate information from STEM disciplines to form or design an innovative product								
I take responsibility of my own learning								
I identify the problem and pose questions								

I plan (participate in planning) for my inquiry					
I apply technology strategically					
I implement discovery learning in a learner-centred environment					
I am engaged in logical reasoning to solve the problem					
I evaluate my product (project) through a design rubric					
I reflect on my learning and modify my plan if needed					
I cooperate and collaborate in an E-STEM team					
I use teachers' (experts') feedback to improve my design (product)					
I discuss, argue and present my project to the classmates					
I consider and integrate information from business with STEM disciplines to make STEM design.					
I study the market to know if my STEM product is needed					
I calculate the costs required for my STEM project /design					
I use STEM outcomes/designs to create or add value /make service to the society.					
I use STEM outcomes/designs to make business and gain profit.					

Section 3: The impact of E-STEM practices on students' entrepreneurial competencies.

To what extent do you agree that E-STEM practices impact the following entrepreneurial competencies?

5= Strongly agree	4= Agree	3= Neither agree nor disagree	2= Disagree	1= Strongly disagree					
Entrepreneurial Competency-Profile of Students					5	4	3	2	1
Category of Knowledge									
. Seeing opportunities: I study and understand the need and requirements of my surrounding to identify opportunities.									
. Financial awareness (literacy): I realize the costs of my project and I understand how to keep the costs of what I do under control									
. Product functionality: I know the extent of my product's ability and benefits to the user.									
. Insight into the market: I know my competitors and/or the equivalent products or projects that provide the same service.									

	Marketing: I am able to introduce my service/product to the market.					
	Category of Skills					
	Creativity: E-STEM lets me suggest new idea and work to produce it through creating new opportunities					
	Planning ability: E-STEM supports my ability to plan and adjust my procedures for better outcomes (projects/products)					
	Critical thinking: it promotes my ability to make connections between ideas and think reflectively to solve problems					
	Problem Solving: I am able to solve the problems I face.					
	Decisiveness: E-STEM classes enhance my ability to make reasonable decision firmly.					
Non-Cognitive Competencies	Persuasiveness: I become capable to argue, persuade and defend my innovative products					
	Building networks (Networkability) (Social orientation): I communicate with group of people who understand the nature of my project in order to approach any of them if needed (ability to make useful connections)					
	Marshalling of resources: I am able to organize resources in order to exploit the most appropriate opportunity to make a business					
	Need for achievement: I have desire to do well in order to attain an inner feeling of personal accomplishment					
	Analysing: I am able to assess different complex situations and interpret the results to draw a conclusion.					
	Category of Attitudes					
	Perseverance: E-STEM practices enhance my persistence ^{SEP} as I should challenge myself to finish what I started (ability to continue despite setbacks)					
	Independence/ self-confidence: E-STEM practices help me to become responsible about my actions and increase my belief that I can achieve my task.					
	Curiosity: E-STEM helps me become inquisitive, search, oriented to learning, attended training courses and ask for experts' help, opinion or advice					
	Initiative (Pro-activity): I am able to take an action towards starting a new business					
	Risk-taking: I am willing to risk a loss and to deal with uncertain situations.					

Appendix (9)

Piloting of STEM Teachers' Questionnaire

Scale 1: Communalities for all items

Communalities

	Initial	Extraction
Q1	1.000	.829
Q2	1.000	.698
Q3	1.000	.573
Q4	1.000	.769
Q5	1.000	.641
Q6	1.000	.685
Q7	1.000	.636
Q8	1.000	.513
Q9	1.000	.761
Q10	1.000	.789
Q11	1.000	.589
Q12	1.000	.598
Q13	1.000	.745
Q14	1.000	.792
Q15	1.000	.598
Q16	1.000	.638
Q17	1.000	.681
Q18	1.000	.641
Q19	1.000	.693
Q20	1.000	.634
Q21	1.000	.753
Q22	1.000	.556
Q23	1.000	.738
Q24	1.000	.712
Q25	1.000	.867
Q26	1.000	.335
Q27	1.000	.743
Q28	1.000	.613
Q29	1.000	.641

Q30	1.000	.615
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Extraction Method: Principal Component Analysis.

Scale 2: Factor Analysis: Internal Validity

Rotated Component Matrix ^a					
Variables	Questions	Component (Factors)			
		1	2	3	4
PBL/PjBL Practices	Q1	.368	-.251	.280	-.117
	Q2	.130	-.355	.376	-.337
	Q3	.468	-.156	.514	-.256
	Q4	.463	.205	.709	.098
	Q5	-.049	-.502	.617	-.083
	Q6	.199	.056	.896	.071
	Q7	.679	-.275	.308	-.067
	Q8	.108	-.620	.314	-.134
	Q9	.521	-.696	.000	.076
	Q10	.075	-.330	.522	.039
	Q11	.148	.021	.660	.173
Value Creation Practices	Q12	-.029	.710	-.222	-.207
	Q13	-.027	.832	-.174	-.151
	Q14	-.107	.872	-.030	-.139
Suggested Practices	Q15	.771	-.001	-.051	.035
	Q16	.528	.178	.020	.166
	Q17	-.012	.199	-.006	.584
	Q18	.010	-.292	.252	.702
	Q19	.317	-.315	-.218	.381
	Q20	.758	-.136	-.058	.195
	Q21	.347	-.087	-.108	.768
	Q22	.081	-.333	.286	.597

Obstacles	Q23	.577	-.019	.194	.095
	Q24	.727	-.227	.324	-.162
	Q25	-.002	.652	.199	.044
	Q26	.073	.542	.188	-.027
	Q27	.224	.493	.667	.069
	Q28	.213	-.121	.171	.154
	Q29	.664	.211	.391	-.045
	Q30	.725	.000	.238	.182

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

Appendix (10)

Quantitative Data Analysis of Teachers' Questionnaire

Scale 1: Reliability of Problem-Based Learning Practices

Reliability Statistics

Cronbach's Alpha	N of Items
.705	11

Item Statistics

	Mean	Std. Deviation	N
item 1: PBL Practices	4.52	.501	154
item 2: PBL Practices	4.39	.598	154
item 3: PBL Practices	4.19	.658	154
item 4: PBL Practices	4.46	.596	154
item 5: PBL Practices	4.76	.429	154
item 6: PBL Practices	3.98	.610	154
item 7: PBL Practices	4.30	.459	154
item 8: PBL Practices	4.32	.483	154
item 9: PBL Practices	4.78	.416	154
item 10: PBL Practices	4.28	.530	154
item 11: PBL Practices	4.47	.550	154

Scale 2: Reliability of Value Creation Practices**Reliability Statistics**

Cronbach's Alpha	N of Items
.831	3

Item Statistics

	Mean	Std. Deviation	N
item 1:VC Practices	2.46	.923	154
item 2:VC Practices	1.47	.951	154
item 3:VC Practices	1.29	.545	154

Scale 3: Reliability of Suggested Practices to incorporate entrepreneurial practices into STEM education**Reliability Statistics**

Cronbach's Alpha	N of Items
.335	8

Item Statistics

	Mean	Std. Deviation	N
item 1: Suggested Practices	3.97	.808	154
item 2: Suggested Practices	2.88	1.096	154
item 3: Suggested Practices	4.23	.613	154

item 4: Suggested Practices	4.13	.773	154
item 5: Suggested Practices	3.67	.667	154
item 6: Suggested Practices	4.33	.472	154
item 7: Suggested Practices	4.29	.571	154
item 8: Suggested Practices	4.69	.462	154

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item- Total Correlation	Cronbach's Alpha if Item Deleted
item 1: Suggested Practices	28.23	4.246	.243	.237
item 2: Suggested Practices	29.32	5.985	-.276	.614
item 3: Suggested Practices	27.97	4.784	.204	.274
item 4: Suggested Practices	28.08	4.085	.328	.185
item 5: Suggested Practices	28.54	4.420	.300	.219
item 6: Suggested Practices	27.88	4.841	.310	.248
item 7: Suggested Practice	27.92	4.731	.262	.252
item 8: Suggested Practices	27.51	5.193	.143	.308

The Reliability of suggested practices after excluding item 2

Reliability Statistics

Cronbach's Alpha	N of Items
.614	7

Item Statistics

	Mean	Std. Deviation	N
item 1: Suggested Practices	3.97	.808	154
item 3: Suggested Practices	4.23	.613	154
item 4: Suggested Practices	4.13	.773	154
item 5: Suggested Practices	3.67	.667	154
item 6: Suggested Practices	4.33	.472	154
item 7: Suggested Practice	4.29	.571	154
item 8: Suggested Practices	4.69	.462	154

Scale 4: Reliability of Obstacles of incorporating entrepreneurial practices into STEM education

Reliability Statistics

Cronbach's Alpha	N of Items
.728	8

Item Statistics

	Mean	Std. Deviation	N
item 1: Obstacles	4.56	.510	154
item 2: Obstacles	3.22	1.005	154
item 3: Obstacles	4.42	.546	154
item 4: Obstacles	2.69	.917	154
item 5: Obstacles	2.57	1.114	154
item 6: Obstacles	4.44	.547	154
item 7: Obstacles	3.18	.939	154
item 8: Obstacles	3.29	.907	154

Scale 5: Total Score Reliability of all questionnaire items

Reliability Statistics

Cronbach's Alpha	N of Items
.857	29

Item Statistics

	Mean	Std. Deviation	N
item 1: PBL Practices	4.52	.501	154
item 2: PBL Practices	4.39	.598	154
item 3: PBL Practices	4.19	.658	154
item 4: PBL Practices	4.46	.596	154
item 5: PBL Practices	4.76	.429	154
item 6: PBL Practices	3.98	.610	154

item 7: PBL Practices	4.30	.459	154
item 8: PBL Practices	4.32	.483	154
item 9: PBL Practices	4.78	.416	154
item 10: PBL Practices	4.28	.530	154
item 11: PBL Practices	4.47	.550	154
item 1: VC Practices	2.46	.923	154
item 2: VC Practices	1.47	.951	154
item 3: VC Practices	1.29	.545	154
item 1: Suggested Practices	3.97	.808	154
item 3: Suggested Practices	4.23	.613	154
item 4: Suggested Practices	4.13	.773	154
item 5: Suggested Practices	3.67	.667	154
item 6: Suggested Practices	4.33	.472	154
item 7: Suggested Practice	4.29	.571	154
item 8: Suggested Practices	4.69	.462	154
item 1: Obstacles	4.56	.510	154
item 2: Obstacles	3.22	1.005	154
item 3: Obstacles	4.42	.546	154
item 4: Obstacles	2.69	.917	154
item 5: Obstacles	2.57	1.114	154
item 6: Obstacles	4.44	.547	154
item 7: Obstacles	3.18	.939	154
item 8: Obstacles	3.29	.907	154

Scale 6: Normality & Homogeneity/ Academic Qualification

Tests of Normality

Variables	Academic Qualification	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Effective Practices	Master	.172	16	.200*	.946	16	.429
	Diploma	.189	12	.200*	.964	12	.843
	Bachelor	.138	126	.000	.937	126	.000
Obstacles of ESTEM	Master	.178	16	.185	.902	16	.085
	Diploma	.153	12	.200*	.917	12	.263
	Bachelor	.122	126	.000	.950	126	.000

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Ind_Dif_EffectiveP_AcaQ	18.136	2	151	.000
Indi_Dif_Obsticales_AcaQ	2.771	2	151	.066

Robust Tests of Equality of Means

	Statistic ^a	df1	df2	Sig.
Indi_Diff_EffectiveP. Welch	134.987	2	27.710	.000

a. Asymptotically F distributed.

Scale 7: Normality & Homogeneity/ Teaching Experience

Tests of Normality

Variables	Teaching Experience	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Effective Practices	1-4 years	.166	60	.000	.886	60	.000
	5-10 years	.189	66	.000	.920	66	.000
	More than 10	.233	28	.000	.859	28	.001
Obstacles of ESTEM	1-4 years	.128	60	.016	.952	60	.020
	5-10 years	.117	66	.025	.946	66	.006
	More than 10	.146	28	.131	.915	28	.027

a. Lilliefors Significance Correction

Test of Homogeneity of Variances through a Non-Parametric Levene's test

	Levene Statistic	df1	df2	Sig.
indiv_diff_Effective P_teaching Exp	.101	2	151	.904
indiv_diff_Obstacles_teaching Exp.	.218	2	151	.804

Scale 8: Normality & Homogeneity/ Subject Taught

Tests of Normality

Variables	Subject taught	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Effective Practices	Science	.231	59	.000	.805	59	.000
	Technology	.249	31	.000	.843	31	.000

Obstacles of ESTEM	Engineering	.243	11	.069	.845	11	.036
	Math	.227	53	.000	.821	53	.000
	Science	.096	59	.200*	.966	59	.099
	Technology	.142	31	.113	.945	31	.111
	Engineering	.203	11	.200*	.876	11	.094
	Math	.160	53	.002	.918	53	.001

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
indiv_Diff_Effect_SubjectT	7.664	3	150	.000
indi_Diff_Obstc_SubjectT	3.040	3	150	.031

Robust Tests of Equality of Means

		Statistic ^a	df1	df2	Sig.
indiv_Diff_Effect_SubjectT	Welch	70.271	3	74.679	.000
indi_Diff_Obstc_SubjectT	Welch	8.726	3	47.637	.000

a. Asymptotically F distributed.

Scale 9: Factor Analysis

Rotated Component Matrix^a

	Component			
	1	2	3	4
item 1: PBL Practices	.275	-.112	.246	.315
item 2: PBL Practices	.330	-.017	.444	-.038
item 3: PBL Practices	.518	.101	.111	.077
item 4: PBL Practices	.243	.855	.125	.053
item 5: PBL Practices	.087	.040	.579	-.147
item 6: PBL Practices	.302	.090	.447	.093
item 7: PBL Practices	.466	-.041	.287	.214
item 8: PBL Practices	.576	.068	.134	.275
item 9: PBL Practices	.143	.043	-.168	.696
item 10: PBL Practices	.363	.133	.251	.107
item 11: PBL Practices	.633	-.034	.105	-.143
item 1: VC Practices	.814	.010	.159	-.061
item 2: VC Practices	.775	.083	.175	.137
item 3: VC Practices	.694	.087	.115	.141
item 1: Suggested	.416	.115	.132	.238
item 2: Suggested	-.471	-.157	-.122	.011
item 3: Suggested	.474	-.015	.178	.222
item 4: Suggested	.085	.004	.668	.031
item 5: Suggested	.198	-.042	.559	.241
item 6: Suggested	.403	.097	.401	.117
item 7: Suggested	.129	.135	.640	-.019
item 8: Suggested	.094	.227	-.020	.701
item 1: Obstacles	.181	.861	.094	.121
item 2: Obstacles	.064	.757	.052	.025
item 3: Obstacles	.105	.891	-.017	-.004
item 4: Obstacles	.750	.199	-.007	-.133
item 5: Obstacles	.387	.473	-.136	-.232
item 6: Obstacles	.116	.895	.003	.017
item 7: Obstacles	-.014	.001	.234	.312
item 8: Obstacles	-.152	.558	.081	.149

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Appendix (11)

Piloting of E-STEM Students' Questionnaire

Scale 1: Reliability Test: Internal Consistency by Kuder-Richardson approach

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.755	.768	4

Item Statistics

	Mean	Std. Deviation	N
Knowledge	.83	.379	53
Skills	.60	.494	53
Attitudes	.79	.409	53
E-STEM Practices	.77	.423	53

Inter-Item Correlation Matrix

	Knowledge	Skills	Attitude	E-STEM Practices
Knowledge	1.000	.353	.512	.596
Skills	.353	1.000	.251	.391
Attitudes	.512	.251	1.000	.612
E-STEM Practices	.596	.391	.612	1.000

I

tem-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Knowledge	2.17	1.067	.615	.406	.670
Skills	2.40	1.052	.392	.176	.801
Attitude	2.21	1.052	.562	.409	.693
E-STEM practices	2.23	.948	.688	.510	.621

Appendix (12)

Validity of E-STEM students' questionnaire

Scale 1: factor analysis

Rotated Component Matrix^a

	Component			
	1	2	3	4
Item 1:E-STEM Practices	.640	-.084	.125	.144
Item 2:E-STEM Practices	.188	.094	.245	.016
Item 3:E-STEM Practices	.256	.025	.483	-.154
Item 4:E-STEM Practices	.661	.038	.305	-.062
Item 5:E-STEM Practices	.112	.172	.532	.032
Item 6:E-STEM Practices	.100	-.040	.455	.045
Item 7:E-STEM Practices	-.001	.053	-.093	.473
Item 8:E-STEM Practices	.088	.030	.474	.254
Item 9:E-STEM Practices	.192	-.058	.671	.187
Item 10:E-STEM Practices	.293	.442	-.021	-.015
Item 11:E-STEM Practices	.235	.045	.305	-.066
Item 12:E-STEM Practices	.449	.295	.301	-.082
Item 13:E-STEM Practices	.765	.038	.015	.136
Item 14:E-STEM Practices	-.006	.138	.252	-.368
Item 15:E-STEM Practices	.155	-.130	.379	.237
Item 16:E-STEM Practices	-.144	-.134	.633	.271
Item 17:E-STEM Practices	-.008	.119	.491	-.034
Item 1: Knowledge	.207	.815	.182	-.021

Item 2: Knowledge	.096	.236	.650	-.030
Item 3: Knowledge	.378	.251	.371	.043
Item 4: Knowledge	.069	.192	.597	-.184
Item 5: Knowledge	.168	.813	.077	.101
Item 1: Skills	.134	.361	.427	.060
Item 2: Skills	.116	.905	.141	.071
Item 3: Skills	.471	.307	.069	-.104
Item 4: Skills	.363	.170	.184	.012
Item 5: Skills	.284	.398	.012	.242
Item 6: Skills	.690	.075	.076	-.060
Item 7: Skills	-.064	.462	.068	.246
Item 8: Skills	.049	.129	.088	.505
Item 9: Skills	.765	.127	.058	-.044
Item 10: Skills	-.017	.886	.080	.056
Item 1: Attitude	.545	.178	.110	.368
Item 2: Attitude	-.068	.213	.277	.764
Item 3: Attitude	.004	.043	.015	.742
Item 4: Attitude	.280	.128	.380	.577
Item 5: Attitude	.482	.042	.136	.336

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Communalities

	Initial	Extraction
Knowledge	1.000	.655
Skills	1.000	.756
Attitude	1.000	.664

Extraction Method: Principal Component Analysis.

Appendix (13)

Quantitative Data Analysis of Students' Questionnaire

Scale 1: Reliability of E-STEM Practices

Reliability Statistics

Cronbach's Alpha	N of Items
.759	17

Item Statistics

	Mean	Std. Deviation	N
Item 1: E-STEM Practices "integrate knowledge from STEM disciplines"	4.59	.497	58
Item 2: E-STEM Practices "take responsibility of my learning"	4.12	.595	58
Item 3: E-STEM Practices "identify the problem & pose a question"	3.57	.704	58
Item 4: E-STEM Practices "plan for my inquiry"	4.33	.574	58
Item 5: E-STEM Practices "apply technology strategically"	4.72	.451	58
Item 6: E-STEM Practices "implement discovery learning"	4.40	.620	58
Item 7: E-STEM Practices "solve problems in a logical reasoning process"	3.91	.657	58

Item 8: E-STEM Practices- "evaluate my product using a rubric"	4.02	.607	58
Item 9: E-STEM Practices- "reflect on my learning and modify my plan"	4.31	.730	58
Item 10: E-STEM Practices "cooperate & collaborate in E- STEM team"	4.67	.473	58
Item 11: E-STEM Practices "use teachers' feedback to improve my product"	4.59	.497	58
Item 12: E-STEM Practices "discuss, argue & present my project"	4.52	.599	58
Item 13: E-STEM Practices "integrate information from business with STEM disciplines"	4.45	.502	58
Item 14: E-STEM Practices "study the market to know my STEM product is needed"	3.86	.661	58
Item 15: E-STEM Practices "calculate the cost"	4.53	.503	58
Item 16: E-STEM Practices "my outcomes add value to the community"	4.47	.503	58
Item 17: E-STEM Practices "use my E-STEM product to make a business"	3.24	.865	58

Scale 2: Reliability of Knowledge

Reliability Statistics

Cronbach's Alpha	N of Items
.722	5

Item Statistics

	Mean	Std. Deviation	N
Item 1: Knowledge Cognitive "seeing opportunities"	4.09	.470	58
Item 2: Knowledge Cognitive "financial awareness"	3.91	.756	58
Item 3: Knowledge Cognitive "product functionality"	4.09	.470	58
Item 4: Knowledge Cognitive "insight into the market"	3.07	.769	58
Item 5: Knowledge Cognitive "ability determination"	4.17	.534	58

Scale 3: Reliability of Skills

Reliability Statistics

Cronbach's Alpha	N of Items
.717	10

Item Statistics

	Mean	Std. Deviation	N
Item 1: Skills Cognitive "creativity"	3.78	.817	58
Item 2: Skills Cognitive "planning ability"	4.10	.519	58
Item 3: Skills Cognitive "critical thinking"	3.93	.588	58
Item 4: Skills Cognitive "problem solving"	4.02	.513	58
Item 5: Skills Cognitive "decisiveness"	3.88	.595	58
Item 6: Skills Non-Cognitive "persuasiveness"	4.07	.672	58
Item 7: Skills Non-Cognitive "social orientation"	3.83	.679	58
Item 8: Skills Non-Cognitive "marshaling resources"	3.66	.870	58
Item 9: Skills Non-Cognitive "need for achievement"	4.07	.672	58
Item 10: Skills Non-Cognitive "analyzing"	4.10	.519	58

Scale 4: Reliability of Attitude

Reliability Statistics

Cronbach's Alpha	N of Items
.721	5

Item Statistics

	Mean	Std. Deviation	N
Item 1: Attitude Non-Cognitive "perseverance"	4.26	.609	58
Item 2: Attitude Non-Cognitive "independence"	4.33	.604	58
Item 3: Attitude Non-Cognitive "curiosity"	4.05	.660	58
Item 4: Attitude Non-Cognitive "initiative"	3.53	.883	58
Item 5: Attitude Non-Cognitive "risk taking"	3.62	.671	58

Scale 5: Total Score Reliability of all questionnaire items

Reliability Statistics

Cronbach's Alpha	N of Items
.886	37

Item Statistics

	Mean	Std. Deviation	N
Item 1: E-STEM Practices "integrate knowledge from STEM disciplines"	4.59	.497	58

Item 2: E-STEM Practices "take responsibility of my learning"	4.12	.595	58
Item 3: E-STEM Practices "identify the problem & pose a question"	3.57	.704	58
Item 4: E-STEM Practices "plan for my inquiry"	4.33	.574	58
Item 5: E-STEM Practices "apply technology strategically"	4.72	.451	58
Item 6: E-STEM Practices "implement discovery learning"	4.40	.620	58
Item 7: E-STEM Practices "solve problems in a logical reasoning process"	3.91	.657	58
Item 8: E-STEM Practices- "evaluate my product using a rubric"	4.02	.607	58
Item 9: E-STEM Practices- "reflect on my learning and modify my plan"	4.31	.730	58
Item 10: E-STEM Practices "cooperate & collaborate in E-STEM team"	4.67	.473	58
Item 11: E-STEM Practices "use teachers' feedback to improve my product"	4.59	.497	58
Item 12: E-STEM Practices "discuss, argue & present my project"	4.52	.599	58

Item 13: E-STEM Practices "integrate information from business with STEM disciplines"	4.45	.502	58
Item 14: E-STEM Practices "study the market to know my STEM product is needed"	3.86	.661	58
Item 15: E-STEM Practices "calculate the cost"	4.53	.503	58
Item 16: E-STEM Practices "my outcomes add value to the community"	4.47	.503	58
Item 17: E-STEM Practices "use my E-STEM product to make a business"	3.24	.865	58
Item 1: Knowledge Cognitive "seeing opportunities"	3.29	.726	58
Item 2: Knowledge Cognitive "financial awareness"	3.91	.756	58
Item 3: Knowledge Cognitive "product functionality"	4.09	.470	58
Item 4: Knowledge Cognitive "insight into the market"	3.07	.769	58
Item 5: Knowledge Cognitive "ability determination"	4.17	.534	58
Item 1: Skills Cognitive "creativity"	3.78	.817	58
Item 2: Skills Cognitive "planning ability"	4.10	.519	58
Item 3: Skills Cognitive "critical thinking"	3.93	.588	58
Item 4: Skills Cognitive "problem solving"	4.02	.513	58

Item 5: Skills Cognitive "decisiveness"	3.88	.595	58
Item 6: Skills Non-Cognitive "persuasiveness"	4.07	.672	58
Item 7: Skills Non-Cognitive "social orientation"	3.83	.679	58
Item 8: Skills Non-Cognitive "marshaling resources"	3.66	.870	58
Item 9: Skills Non-Cognitive "need for achievement"	4.07	.672	58
Item 10: Skills Non-Cognitive "analyzing"	4.10	.519	58
Item 1: Attitude Non- Cognitive "perseverance"	4.26	.609	58
Item 2: Attitude Non- Cognitive "independence"	4.33	.604	58
Item 3: Attitude Non- Cognitive "curiosity"	4.05	.660	58
Item 4: Attitude Non- Cognitive "initiative"	3.53	.883	58
Item 5: Attitude Non- Cognitive "risk taking"	3.62	.671	58

Scale 6: Factor Analysis

Rotated Component Matrix ^a				
	Component			
	1	2	3	4
Item 1: E-STEM Practices "integrate knowledge from STEM	.681	-.129	.131	.032

disciplines"				
Item 2: E-STEM Practices "take responsibility of my learning"	.261	.096	.302	.190
Item 3: E-STEM Practices "identify the problem & pose a question"	.301	.010	.457	.086
Item 4: E-STEM Practices "plan for my inquiry"	.641	-.048	.234	.208
Item 5: E-STEM Practices "apply technology strategically"	.208	.243	.542	-.114
Item 6: E-STEM Practices "implement discovery learning"	.070	-.149	.436	.324
Item 7: E-STEM Practices "solve problems in a logical reasoning process"	.061	.045	-.002	.301
Item 8: E-STEM Practices-"evaluate my product using a rubric"	.017	.045	.558	.254
Item 9: E-STEM Practices-"reflect on my learning and modify my plan"	.108	.048	.724	.166
Item 10: E-STEM Practices "cooperate & collaborate in E-STEM team"	.490	.277	-.027	.075
Item 11: E-STEM Practices "use teachers'	.143	.217	.361	-.014

feedback to improve my product"				
Item 12: E-STEM Practices "discuss, argue & present my project"	.680	.229	.205	-.044
Item 13: E-STEM Practices "integrate information from business with STEM disciplines"	.767	-.028	-.133	.158
Item 14: E-STEM Practices "study the market to know my STEM product is needed"	-.044	.028	.145	.102
Item 15: E-STEM Practices "calculate the cost"	.161	-.034	.526	-.120
Item 16: E-STEM Practices "my outcomes add value to the community"	-.115	-.136	.633	.328
Item 17: E-STEM Practices "use my E-STEM product to make a business"	.016	.055	.464	.093
Item 1: Knowledge Cognitive "seeing opportunities"	.308	.813	.155	.012
Item 2: Knowledge Cognitive "financial awareness"	.184	.225	.613	.054
Item 3: Knowledge Cognitive "product	.552	.164	.279	.019

functionality"				
Item 4: Knowledge Cognitive "insight into the market"	.063	.178	.609	-.086
Item 5: Knowledge Cognitive "ability determination"	.200	.890	.174	.097
Item 1: Skills Cognitive "creativity"	.170	.276	.288	.393
Item 2: Skills Cognitive "planning ability"	.087	.931	.141	.148
Item 3: Skills Cognitive "critical thinking"	.511	.262	.072	-.024
Item 4: Skills Cognitive "problem solving"	.493	.179	.142	.024
Item 5: Skills Cognitive "decisiveness"	.292	.274	-.069	.309
Item 6: Skills Non-Cognitive "persuasiveness"	.726	.085	.090	-.125
Item 7: Skills Non-Cognitive "social orientation"	.038	.416	.024	.290
Item 8: Skills Non-Cognitive "marshaling resources"	-.054	.070	.135	.569
Item 9: Skills Non-Cognitive "need for achievement"	.726	.085	.090	-.125
Item 10: Skills Non-Cognitive "analyzing"	.087	.931	.141	.148
Item 1: Attitude Non-Cognitive	.571	.108	-.020	.271

"perseverance"				
Item 2: Attitude Non-Cognitive "independence"	.005	.148	.184	.817
Item 3: Attitude Non-Cognitive "curiosity"	-.007	.041	-.038	.800
Item 4: Attitude Non-Cognitive "initiative"	.222	.104	.351	.653
Item 5: Attitude Non-Cognitive "risk taking"	.422	.015	.193	.332
Extraction Method: Principal Component Analysis.				
Rotation Method: Varimax with Kaiser Normalization. ^a				
a. Rotation converged in 6 iterations.				

Scale 7: Normality: Pre/Post-test for both Control & Experimental Group

Tests of Normality							
Variables	Independent	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pre-ESTEM P.	Control	.073	55	.200*	.982	55	.581
	Experiment	.092	58	.200*	.974	58	.241
Post-ESTEM P.	Control	.87	55	.200*	.983	55	.610
	Experiment	.92	58	.200*	.947	58	.241
Pre-Entrepreneurial C.	Control	.084	55	.200*	.942	55	.431
	Experiment	.087	58	.200*	.983	58	.501
Post-Entrepreneurial C.	Control	.107	55	.200*	.978	55	.201
	Experiment	.158	58	.200*	.917	58	.242
Pre-Knowledge	Control	.145	55	.184	.902	55	.132
	Experiment	.161	58	.200*	.921	58	.001
Post-Knowledge	Control	.126	55	.200*	.956	55	.404
	Experiment	.138	58	.200*	.958	58	.301

Pre-Skills	Control	.134	55	.186	.956	55	.164
	Experiment	.143	58	.200*	.948	58	.204
Post--Skills	Control	.147	55	.183	.933	55	.144
	Experiment	.157	58	.200*	.929	58	.202
Pre-Attitude	Control	.135	55	.187	.944	55	.103
	Experiment	.155	58	.200*	.935	58	.404
Post-Attitude	Control	.127	55	.185	.957	55	.409
	Experiment	.145	58	.200*	.937	58	.502

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction