Investigating the Themes and Perceptions of the Formal and Informal STEM Education Programs, STEM Career Development, and their Connections to the Triple Helix Component in the UAE

التحقق من موضوعات وتصورات ستيم المنهجي وغير المنهجي وتطوره الوظيفي وارتباطاتها بمكون الحلزون الثلاثي في دولة الإمارات العربية المتحدة

by

FATIMA YOUSUF HUSAIN

A thesis submitted in fulfilment

of the requirements for the degree of

DOCTOR OF PHILOSOPHY IN EDUCATION

at

The British University in Dubai

January 2022

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Thesis Supervisor
Professor Sufian A. Forawi

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ABSTRACT

Background: The Triple Helix model creates collaborative relationships between its three components: government, university and industry. Through the cooperation of the Triple Helix actors, the conditions for knowledge production are made possible. A knowledge-based economy is necessary to promote innovation to achieve economic growth and stability. As a result, the needs of the future economy emphasize a growing demand for a STEM workforce. Globally, Science, Technology, Engineering and Mathematics (STEM) education has increased in popularity as a learning approach to address this gap. The Triple Helix model plays a vital role to benefit STEM education and increase the STEM workforce. In the UAE, the Economic Vision 2030 emphasizes developing STEM education to meet future workforce needs, creating an opportunity to use the Triple Helix model to improve STEM education and to develop future STEM careers.

Purpose: The main purpose of the study is to investigate the common themes related to the formal and informal STEM education and stakeholders' perceptions and responses on formal and informal STEM education programs, STEM careers and the Triple Helix model in the UAE.

Methods: The researcher employed exploratory sequential mixed methods approach for this study. The mixed research methods included both qualitative and quantitative methods. These include document analysis, questionnaires and semi-structured interviews. For the document analysis, 5 national and global policy documents from countries excelling in STEM education were analyzed for themes. For the questionnaire, 123 leaders/teachers, 101 parents, and 361 students from the governmental school cluster participated. For the industry cluster, 53 leaders/teachers and 101 students participated. For the university cluster, 54 leaders/teachers and 110 students participated. Interviews were then conducted with leaders and teachers from the government, industry and university clusters. There were 15 participants from governmental schools, 7 from industry institutions and 7 from universities.

Results: The findings of this study included a positive perceptions of STEM education programs and STEM careers from the participants in all clusters. The study found that the implementation of STEM education programs would increase motivation by encouraging students and help to drive their interests towards STEM disciplines. Additionally, the stakeholders emphasized the importance of STEM education programs to prepare students for future jobs, which can benefit from the Triple Helix model. Also, there was no difference between male and female students regarding STEM career perceptions in all three Triple Helix clusters. The findings showed that there is a need for the Triple Helix components to play a larger role in STEM education to improve its implementation in the governmental schools and to increase the number of students pursuing STEM careers. To build student capacity and motivation, more incentives are needed to encourage students in the governmental schools to pursue STEM careers. Currently, schools need to collaborate with universities and industries for the benefit of STEM education. There is room for improvement due to the fact that partnerships are based on the region and the resources available.

Implications/Contributions: To meet the needs of a growing demand for a future STEM workforce, policymakers can use the Triple Helix model to enhance formal and informal STEM education programs and increase the number of students pursuing STEM careers. This will improve the knowledge-based economy that is necessary to achieve the UAE's Vision 2030.

Key words: Triple Helix model, formal and informal STEM education, career development

الخلاصة

خلفيّة الدّراسة: يُنشئ نموذج هيلكس الثلاثيّ علاقات تعاونيّة بين مكوناته الثلاثة: الحكومة والجامعة والصناعة، والتعاون بين العناصر الثلاثة يهدف الى تمكين الاقتصاد المعرفيّ؛ لتعزيز الابتكار والنموّ الاقتصاديّ، والذي يركّز على احتياجات المستقبل إلى الطلب المتزايد على القوى العاملة في مجال (ستيم)، والمرتكز على موادّ العلوم والتكنولوجيا والهندسة والرياضيّات. وقد ازدادت عالميّا شعبية تعليم العلوم والتكنولوجيا والهندسة والرياضيات (ستيم) كنهج تعليميّ؛ لتحقيق أهداف الدول، وفي دولة الإمارات العربية المتحدة تؤكّد الرؤية الاقتصاديّة 2030 على تطوير تعليم العلوم والتكنولوجيا والهندسة والرياضيات من أجل تلبية احتياجات القوى العاملة المستقبليّة، وإيجاد المُناخ المُلائم استخدام نموذج هيلكس الثلاثيّ لتحسين تعليم العلوم والتكنولوجيا والهندسة والرياضيّات.

غرض الدّراسة: الغرض الرئيس من الدراسة هو الاطّلاع على آراء أصحاب المصلحة في برامج (ستيم) المنهجية وغير المنهجية المتعلّقة بالتعليم، والمهن المستقبلية الخاصّة بـ (ستيم)، ومثلث هيلكس الثلاثيّ في دولة الإمارات العربية المتحدة.

منهج الدّراسة: استخدمت الباحثة أساليب بحث استكشافية متتابعة ومتنوعة، وتتضمن هذه الأساليب البحثيّة كلا الأسلوبين الكميّ والنوعيّ، وتشمل تحليل الوثائق والاستبانات والمقابلات، وقد تمّ تحليل 5 وثائق خاصّة بسياسات وطنيّة وعالميّة في البُلدان المتفوقة في التعليم. وقد شارك في الاستبانة 123 معلمًا / قائدًا، و101 وليُّ أمر، و361 طالبًا من مجموعة المدارس الحكوميّة، أمّا فيما يتعلّق بمجموعة الصناعة فقد شارك 53 مدرسًا / قائدًا و101 طالبٌ، وبالنسبة إلى المشاركة الجامعيّة فقد شارك 54 قائدًا / معلمًا و110 طلابٍ، ثم أُجريت المقابلات مع المعلمين القادة من الحكومة والصناعة والجامعات، مثّلهم 15 مشاركًا من المدارس الحكومية، و7 من الصناعة و7 من الجامعات.

نتائج الدّراسة: تضمنّت نتائج هذه الدراسة تصوّرًا إيجابيًّا لبرامج (ستيم) التعليميّة، والمهن الخاصّة به من قِبQلِ المشاركين جميعا. وأثبتت الدّراسة أيضًا أنّ نموذج هيلكس الثلاثيّ من شأنه أنْ يزيد الحافز التعليميّ من خلال تشجيع الطلاب، وتوجيه اهتماماتهم إلى التّخصّصات الخاصّة بـ (ستيم)، وبالإضافة إلى ذلك أكّد أصحاب المصلحة على أهميّة تعليم (ستيم) لإعداد الطلاب للوظائف المستقبليّة بمساعدة نموذج الحلزون الثلاثيّ أيضًا، كما تبيّن أنّه لم يكن هناك فرق بين نتائج الاستطلاع فيما يتعلق بالتصوّرات المهنيّة الخاصّة بـ (ستيم) لدى المجموعات الثلاث من الطلاب والطالبات. وقد أظهرت النتائج كذلك أنّ هناك حاجة إلى أنْ تلعب مكوّنات نموذج هيلكس الثلاثيّ دورًا أكبر في تعليم (ستيم) لتحسين تنفيذه في المدارس الحكوميّة، وزيادة عدد الطلاب الذين يتابعون وظائف (ستيم)، ويحتاج هذا التركيز إلى تحفيز الطلاب والطالبات، وتحتاج المدارس أيضًا إلى التعاون مع الجامعات والصناعات لصالح تعليم العلوم والتكنولوجيا والهندسة والرياضيّات.

استنتاجات ومساهمات الدّراسة: من تصوّرات أصحاب المصلحة أظهر البحث أنّ التعاون والتواصل بين مكوّنات نموذج هيلكس الثلاثيّ سيعزز برنامج (ستيم) المنهجي وغير المنهجي تعليم العلوم والتكنولوجيا والهندسة والرياضيات، وزيادة عدد الطلاب الذين يطمحون إلى وظائف خاصّة بمجالات العلوم والتكنولوجيا والهندسة والرياضيات، وسيؤدّي هذا بدوره إلى تحسين الاقتصاد القائم على المعرفة اللازم لتحقيق رؤية الإمارات العربية المتحدة 2030.

الكلمات الأساسية: نموذج هيلكس الثلاثي، برامج ستيم المنهجي وغير المنهجي المتعلقة بالتعليم في مجالات العلوم والتكنولوجيا والهندسة والرياضيات، مهن مستقبلية خاصة بستيم في مجالات العلوم والتكنولوجيا والهندسة والرياضيات

Dedication

As an appreciation of their constant support, I dedicate this thesis to my family and to all who provided inspiration and encouragement.

To my sister, Fakria, whose cognitive research pursuits sparked my own academic path.

To my father, Yousif, whose encouragement guided me every step of the way.

Although they are not with me now to see the completion of my doctoral thesis, they were with me all throughout my studies and I could not have completed it without them.

Acknowledgements

This doctoral thesis represents a journey filled with intense moments of hard work and persistence, various stages filled with ups and downs and hindrances that were to be jumped over. Along with the efforts put towards this piece of work, there were many moments of joy and pride throughout. It took four years to complete this achievement. Hence, I take this opportunity to express my deep feelings towards all those who supported me in every part of it. First, I would like to acknowledge and express my sincere gratitude to Professor Sufian Forawi, who has always supported and guided me throughout the dissertation process. Second, I would like to thank my parents and family for their unlimited support and encouragement in all the different stages; a special message of gratitude goes towards my husband and children, Saeed, Alyazia, Mohammad, Mariam and Rashid. All in all, I thank the British University in Dubai for giving me this unique opportunity to explore a field of study and be able to deeply research and present a thoroughly written research project.

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DEFINITIONS

Terms	Definitions of key concepts related to the research
Cycle2 & Cycle3	Cycle 2 includes students in the middle school level from Grades 5 to 8. Cycle 3 includes students in the high school level from Grades 9 to 12.
Formal STEM program	STEM program included in the government schools
Informal STEM program	STEM programs outside of the government school curriculum
Industry	Institutions that support the informal STEM programs outside of the government schools
Triple Helix Model	The collaboration between three institutional clusters: government, industry and university

CHAPTER 1: Introduction

With the creation of a knowledge-based society, economic development can be achieved. This process can be fostered with the Triple Helix model, which represents the collaboration between the government, university, and industry (Cai & Etzkowitz 2020). It is a spiral model of innovation, and its roots can be traced back to the 18th century, through the actions of the New England Council in the US. The New England Council, which represented business, academic, and political leaders, acted on the concept of the knowledge-based regional economic development. For instance, universities such as Harvard and MIT established new firms from scientific research using their academic base. These fledgeling university-industry partnerships needed stronger organizational support, which New England's business and political leaders welcomed due to the failings of the traditional business models to produce regional development in the 1930's (Cai & Etzkowitz 2020).

In the 1990s, Etzkowitz and Leydesdorff (1995) conceptualized the Triple Helix model as the triadic relationship between university, industry and government. It built on the works of Sábato and Mackenzi, along with the works of Lowe (Smith & Leydesdorff 2014). Momeni, Yazdi and Najafi (2019) emphasize that the Triple Helix model focuses on mutual interactions between the Triple Helix actors that recognizes the changing nature of innovation. The Triple Helix model makes it possible to understand how the three actors coordinate in concrete actions (Ehlers 2020) to enable economic development and innovation in a knowledge-based society (Smith & Leydesdorff 2014). Leydesdorff (2010) points out that the Triple Helix model reveals the subdynamics that compose a knowledge-based economy. The three sub-dynamics are identified as: (1) wealth generation in the economy, (2) new developments produced by organized science and technology and (3) supervision of the interactions between the two previous sub-dynamics by the government in both the public and private domain.

The three systems, economic, academic and political, are subsystems of society that operate relatively autonomously and with different mechanisms. Leydesdorff (2010) recognizes that the three institutions of the Triple Helix model comprise a dual-layered network of relationships: the first layer being their constraint on each other's behavior and the second layer being their ability to shape each other's expectations. This model is differentiated both horizontally and vertically. It functions horizontally through the different coordination mechanisms that are operating each other and vertically through the structure of information that can develop along the collaborative approach.

In the current competitive climate of globalization, capitalizing on knowledge has become crucial for modern economies. Issues regarding economic growth and technological development are now being addressed through the collaborative efforts of the Triple Helix components (Khan & Ahmad 2020). The collaboration in the Triple Helix model creates the conditions for knowledge production to be organized through partnerships between the actors (Romanowski 2020), and these infrastructures provide different approaches for improving the knowledge-based economy through innovation (Khan & Ahmad 2020). These institutional actors function in concert to develop research and pursue development and innovation initiatives that work towards commercialization of intellectual property (Wonglimpiyarat 2015). Universities play a role in creating a knowledge-based economy through academic research interactions with the other Triple Helix actors (Saad, Guermat & Boutifour 2020). Innovative capacity is further supported by industry since partnerships increase private sector productivity (Rowland-Jones 2016). The government also develops the Triple Helix partnerships by supporting initiatives and regulations for research and development, simultaneously advancing education and the future workforce (Ankrah & Omar 2015; Committee on STEM Education 2018).

According to Etzkowitz and Zhou (2017), the relationship between the university-industry-government creates an advantageous design for entrepreneurship and innovation that enables transferring research into use (Etzkowitz & Zhou 2017). Universities as institutions for creation and exchanging information related to technology and science play an important role for generating different problem-solving elements through innovation. Entrepreneurial universities become research bases and social and economic development can be enhanced by capitalizing on the intellectual property (Etzkowitz & Zhou 2017). This emphasizes how the collaboration, which is mechanized by a dynamic that is simultaneously autonomous and overlapping, between the three actors has become an imperative element for innovation (Etzkowitz & Zhou 2017).

In addition to knowledge production, the three strands of the Triple Helix model improve local economies by promoting growth through the generation of technology (Etzkowitz & Zhou 2017). An example of this organized knowledge-based dynamic is research and development (R&D) laboratories. The evolution of a knowledge-based economy evolves through the productive force of innovation by making new alternatives available as derived from the new knowledge generated. Knowledge-based innovation can in turn be globalized and facilitate change by driving new perspectives (Leydesdorff 2010). During this process, the relevant institutions undergo organizational hybridization as independent and interdependent functioning coexist to meet consensual objectives as they create diversified knowledge that can change the world (Etzkowitz & Zhou 2018). For instance, academic entrepreneurship extends a university’s long-established role of teaching and research to include a more active role in technology creation, a role traditionally played by industry (Etzkowitz & Zhou 2018). Recursive communication and complex co-evolution between universities, industries and governments are permanent features of the Triple Helix model (Etzkowitz & Zhou 2018). In short, the cooperation amongst these entities is directed towards establishing a knowledge-based economy through innovation (Sarpong et al. 2017). As the knowledge-based era replaces the industrial society, there is a growing involvement of knowledge-creating institutions and their highly educated personnel in the innovation process (Etzkowitz & Zhou 2018).

The Triple Helix model has gained traction in international scientific circles during the past two decades (Momeni, Yazdi & Najafi 2019). Ranga and Etzkowitz (2015) specified that the Triple Helix system is an evolutionary process that contains a transition from a static stage to a laissez faire state in which governments can influence academic and industry sectors to develop an association between these three institutional components. Finally, a hybrid stage is reached when the different institutional members maintain their uniqueness along with consideration of the role of the others. Globally, the Triple Helix model has differing levels of collaboration amongst the components. Some factors include: reaction to the demands of an innovative economy, level of readiness to interact with universities as centres of ideas-generation and outdated technological enterprise (Oplakanskaia et al. 2019).

According to the World Economic Forum (2016), new advances in science and technology will result in drastic changes in the environment and alter human functioning. Al Murshidi (2020) warned that nations that are unprepared with the adequate skills and knowledge will not thrive in the digitalized and globalized world economy. To prepare for this industrial revolution powered by technology, learning institutions worldwide have transferred their focus on training students in science, technology, engineering and mathematics (STEM) fields (Wan-Husin et al. 2016). This presented the key element for promoting innovation in the schooling system (Sellami et al. 2017; Wells 2019). STEM is an integrated and interdisciplinary learning approach that has the potential to enhance learning experiences for students by connecting classroom learning to real world issues (Ahmed 2016).

McDonald (2016) emphasized that the focus on STEM-based education is to develop qualified graduates. This aim will have a positive influence in any country as it creates the workforce required to handle its needs (Wan-Husin et al. 2016). Ritz and Fan (2015) reported that STEM education takes on a responsive approach to economic challenges globally because it is designed towards generating the necessary skills that are needed in the present circumstances. Challenges related to energy, technology, economy and climate can be addressed using STEM education since it provides students with the opportunity to think across multiple disciplines. With STEM, solving real-life issues through the teaching of sciences, technology, engineering, and mathematics makes the education content more relevant. As a result, the next generation will be more prepared to confront the current and future realities impacting society while raising the economic status of the country (Radloff & Guzey 2016; Shernoff et al. 2017).

Due to STEM education's potential for developing the growth and development of economies by producing well-qualified graduates (Hathcock et al. 2015), it also creates the opportunity for the UAE to achieve their goals for innovation (Ashour 2020). As a developing nation with a growing economy, the UAE prioritizes a high-quality education for its citizens which impacts both the students and the national economy. For instance, twenty percent of the government's total budget was reserved for general, higher, and university education programs in 2018 (Al Murshidi 2020). According to Kamal (2018), the importance of the education sector is made apparent in the current strategic plan for 2017-2021 that seeks to raise the high school graduation rate from 96.7% in 2016 to 98% in 2021.

Abbas (2019) cited a 2018 report by the Boston Consulting Group predicting that the UAE's educational sector will grow from $4.4 billion in 2017 to $7.1 billion by 2023.

The UAE's national goals include preparing students to compete internationally. An example of this is the UAE's intention to rank in the highest performing countries in the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). For PISA, the goal is to be in the top 20 and for TIMSS, the goal is to be in the top 15 (Kamal 2018; PWC 2019). These internationally standardized tests measure student achievement in math and science, tracing the improved performance of UAE students in STEM fields (Schleicher 2019). Due to the UAE's national vision to develop human capital (Nurunnabi 2017), the impact of teachers' education on student learning has become a priority (Shaukat, Vishnumolakala & Alghamdi 2020). One aspect that has been considered is the concept of teacher self-efficacy, which is the teachers' belief in their capability to teach science using new strategies that can increase student achievement on the TIMSS and PISA international exams (Shaukat, Vishnumolakala & Alghamdi 2020). A second method is embedding entrepreneurial practices into STEM education to prepare students to compete internationally. Eltanahy, Forawi and Mansour (2020) identified that taking on a more business-like approach to STEM education will provide students with the relevant entrepreneurial experiences that can support the UAE's target to advance a knowledge-based economy.

After 2010, the Next Generation Science Standards (NGSS) was adopted by many educational institutions and marked the initiation of STEM education in the UAE (Al Murshidi 2020). This is in line with the UAE's leaders emphasizing that human resources are critical in achieving the nation's goals of development across different sectors (UAE Government 2015). STEM education is vital since the World Economic Forum (2016) estimates that 65% of children currently entering primary school need to be trained with new skills as the jobs that currently exist today will become obsolete in the future. Additionally, the UAE Society of Engineers acknowledged that at least 60,000 extra engineers will be needed between 2011 and 2020, a demand that can only be met with STEM integration in schools. As a result, two initiatives were launched in 2018, the National Advanced Sciences Agenda 2031 and the 2021 Advanced Science Strategy, which are components of Agenda 2031. The 2031 Agenda endeavors to use the advanced sciences to create solutions to future challenges and use strategies to meet the objectives of Vision 2021 and the Centennial Plan 2071 (UAE Government 2021). There is a focus on innovation through the creation of supportive technology and entrepreneurship in science and technology (UAE Government 2021). Education in the UAE must address the technological changes and the skills students need for the future, which STEM education offers (Elsholkamy 2018). Formal STEM education programs can collaborate to share best practices to face these challenges. Additionally, informal STEM education programs can experiment with the STEM curriculum to improve teaching approaches that can later be transferred into the classroom setting (Shaer, Zakzak & Shibl 2019).

Al Murshidi (2020) acknowledges that thousands of Emirati STEM graduates are needed since government policies are working towards expanding an economy reliant on Emirati nationals, implying that education needs to enact strategic reforms. In this endeavor, the tripartite structure of the Triple Helix model can help to meet this demand (Son 2017). The innovative potential of the Triple Helix actors contributes to economic development and job growth by supporting students to cultivate new skills and entrepreneurial talent (Ranga & Etzkowitz 2013). Additionally, new technologies are needed so that students can upgrade their learning through experimentation and design thinking (Kim 2017). As a result, fostering STEM skills can be supported by the Triple Helix model. The UAE Government (2015) makes the connection between creating the appropriate environment and achieving goals for innovation. With the implementation of STEM education through the collaboration of the Triple Helix actors, the elements that promote and enable innovation such as regulatory frameworks, comprehensive enabling services and technology infrastructures can be established.

To better determine the Triple Helix's role in improving STEM educational programs and increasing STEM jobs, the perceptions of stakeholders need to be considered. Moonesar et al. (2015) prioritized understanding the satisfaction levels of cycle 2 and university students regarding STEM education to understand the obstacles preventing them from pursuing a STEM degree or career. For cycle 2 students, encouragement from parents and peers improved their perceptions of their science identity and abilities, which in turn increased the likelihood of pursuing a STEM major. Furthermore, the students' perceptions of their abilities and their views regarding the rigor of STEM subjects has shown to create obstacles (Moonesar et al. 2015). For instance, it is clear that students understand the value of STEM, however, the lower participation in STEM programs do not reflect this. As a result, it is important to learn more about the factors influencing the students' choices. Students need more support so that they can establish a science identity that will motivate them to pursue STEM educational programs and STEM careers (Moonesar et al. 2015).

Additionally, it wasn't clear if the university students found the career resources useful or significant to their job search. It is evident that innovative solutions to improve STEM education and increasing the STEM labor force can benefit from the stakeholders' values and opinions. The strength of the Triple Helix model to benefit STEM education and STEM careers comes from targeting the needs identified by the stakeholders such as designing learning experiences to attract students to STEM fields and retaining students to pursue STEM careers by providing internship support and STEM awareness.

In order to create the educational reforms needed to achieve the UAE's Vision 2030, the Ministry of Education's assessment guide for STrEaM policy (n.d.) aims to improve learning outcomes by raising the standards of teaching, learning and assessment in STrEaM education. One key need highlighted by the first document is the creation of local community and industry partnerships. Key institutional players such as universities and government were left unmentioned. In contrast, international STEM policy documents from various countries have explicitly mentioned the Triple Helix collaboration as essential to their goals of developing formal and informal STEM education programs to increase the future STEM workforce (Bruton 2017; Vought 2018).

1.1 Background of the Research

According to Gallagher (2019), the development of the UAE's educational system can be divided into two phases: the first being quantitative expansion and the second being qualitative transformation. From the 1970s to until the end of the 1990s, the UAE experienced a massive growth in schools, students and teachers. Following the initial expansion, the qualitative improvement phase focused on public school reforms and the improvement of higher educational institutions. The transition between the educational phrases has been rapid. Cycle 2 and cycle 3 enrollment between 1973 to 2009 rose from 22% to 93%. Additionally, literacy rates have soared. In the 1970s, at the founding of the UAE, 48% of adults were illiterate and 40 years later, over 93% are literate (Crown Prince Court 2011, cited in Molotch & Ponzini 2019). On the international scale, the UAE can be seen outperforming neighboring countries. In 2016, the UAE achieved the highest score amongst all Arab countries in the Progress in International Reading Literacy Study (PIRLS), an international test of reading proficiency. Despite all the academic achievements attained in such a short time frame, there is still room for further growth. On an international scale, the UAE does not meet the international average for student achievement (Gallagher 2019).

The government pushed for STEM education reform through the use of national strategic measures and spread through all of the emirates of the UAE (Shaer, Zakzak & Shibl 2019). STEM education introduces a holistic view which will better prepare students for 21st century jobs (Singh 2019). Ridge, Kippels and Farah (2017) reviewed the various reforms made in the UAE to improve the education system. The study identified curriculums as the major barrier to prevent reforms. The number of practical subjects taught in the UAE are limited and the study identified the need of introducing practical and applicable curriculums in schools that are not restricted to text-book instruction only. STEM education is a curriculum that moves away from rote memorization. As Soomro (2019) observed, STEM education is a curriculum of research-based pedagogy rather than lecture-based teaching pedagogy. However, the application of effective pedagogical studies remains a challenge that has yet to be achieved to actualise STEM education. However, the need to implement STEM education is vital because it prepares students for the future labor market with its focus on 21st century skills and technology (Manyika, Chui & Miremadi 2017).

Developing Emirati citizens who are knowledgeable and innovative has become increasingly pronounced in recent educational policies to prepare the UAE for a post-oil world that progresses towards economic diversification (Gallagher 2019; UAE Government 2015). Al Murshidi (2020) highlights that formal and informal STEM education programs can benefit from improving the quality of STEM teaching and learning. Therefore, the UAE's educational system needs to be effectively developed to promote highly talented workers to attain the future vision for self-sustainability and development of an innovative economy (Gallagher 2019; MOE 2019). For instance, in 2006, the Economic Vision 2030 was developed to create a common framework that aligns policies that fully engage the private sector. The initiative creates partnerships between stakeholders from the public sector and the private sector. Human development is the driving force behind the initiatives and policies, therefore ensuring a high-quality education is prioritized (British Council 2018). Additionally, the National Strategy for Higher Education 2030, launched by the Ministry of Education, acknowledged that to boost the economy in private and public sectors, there is a dire need to provide future generations with the right skill set, which includes practical and technical skills. One of the strategy's goals is to produce a workforce of professionals developed in the Emirates to sustain the growth in important sectors like economy, development of the UAE, entrepreneurship and knowledge (MOE 2019).

The workforce in this country forms its greatest resource (Albalooshi & May 2018). However, employment is affected by the students' declining interest in STEM fields (Gallagher 2019). According to the most recent report from KHDA (Trines 2018), 59% of college graduates are earning degrees in business, while 14.8% are in engineering and only 6.1% are in technology. This percentage is very low in comparison to countries which put innovation as a priority, such as Korea with 57% enrolment or the US where 63% of the enrolment is in science and engineering. Globally, STEM jobs are expected to have the most rapid growth from 2014 – 2024. The highest rates are occupied by computers, the biomedical field, statisticians, and mathematics. It can then be inferred from this data that there is and will be an ongoing and growing demand for STEM majors (Singh 2019).

At the high school level, the PISA 2012 study concluded that 15-year-old in the UAE ranked 48th (out of 65) when compared against their international counterparts in mathematical literacy. Furthermore, when compared to countries belonging to the Organisation for Economic Co-operation and Development (OECD), the UAE measured 60 points lower than the average (Moonesar, Saher & Mourtada 2015). Recognizing the need to advance sciences to create and develop solutions for future challenges, the UAE government launched the National Science Agenda 2031 (Shaer, Zakzak & Shibl 2019). Four enablers that the plan designed to expand are: supportive technology, economic information services, entrepreneurship in science and technology and a collaborative scientific community. The priorities included national capacity-building, developing an advanced industry sector and creating a strategic industries complex (Shaer, Zakzak & Shibl 2019).

In 2015, the UAE government announced it as the Year of Innovation, which is crucial in promoting the national innovative ecosystem that the nation is striving for (Eriksson 2015). Aiding in this endeavor is the National Research Foundation (NRF) that was established in 2008 to promote research activity by individuals or teams of researchers in private and public universities, colleges, centers, institutes and companies (NRF 2019). Advancing knowledge powers, the transformative potential of innovation and all three Triple Helix actors must be engaged because they all have roles and responsibilities (Ahmed & The 2015). The result of Triple Helix partnerships includes the creation of policies for intellectual property and R&D, availability of financing and the strengthening of the technological infrastructure. Collaboration between the Triple Helix actors builds innovation capacity and creates competition and economic growth (UAE Government 2015; Wonglimpiyarat 2015). Like the STEM policy documents from other countries, the UAE also sees the potential in the collaboration between the Triple Helix components. Such partnerships between the university, industry and government can help to facilitate the students' STEM identity formation and STEM aspirations by providing exposure to role models, creating extracurricular activities and by building career support (Moonesar et al. 2015; Williams 2016).

The Triple Helix model's multi-pronged approach in encouraging entrepreneurship is seen in South Korea's university-industry partnership between Sungkyunkwan University (SKKU) and Samsung. Samsung supplies technological equipment, such as software and laptops, while SKKU participates as a part of Samsung's human resources system (Stek

2015). In China, the subway equipment industry partnered with local universities to localize and cut cost on production (Gao 2015). Similarly, the UAE will need to utilize the Triple Helix model to develop technology, science and innovation capacity. Through the acknowledgement of the Triple Helix model's effects on future careers, the UAE can advance the regional vision and incorporate effective change in the drivers in order to attain an efficient and knowledge-based economy (Esposito, Elsholkamy & Fischbach). The national efforts to develop STEM roles have potential, but they need to be strengthened to enable the country to achieve its industrial development plans and ambitions. The Triple Helix model supports the UAE's goals by developing the appropriate skills needed to establish a strong local workforce and improve economic growth by funding and managing R&D enterprises (UAE Government 2015). The relationship between the Triple Helix components, (university-industry-government), STEM education and their influence in student career choices is worth investigating because this model can continue to build human capacity, diversify the economy and create a knowledge-based economy that is globally competitive as the UAE continues to move towards a post-oil era.

1.2 Problem Statement

According to the British Council (2018), there is a global need for educational systems to support students by preparing them for future jobs. Accordingly, the UAE government is invested in designing a STEM education model that sufficiently prepares students for STEM professions to compete globally (dem Moore, Chandran & Schubert 2018), it is necessary to understand the factors influencing students to pursue STEM fields. The Mohammed bin Rashid School of Government found a relationship between a positive perception of STEM subjects and the intention to enroll in STEM majors at the university level (Moonesar, Saher & Mourtada 2015). To attract and retain students in STEM fields, the lack of STEM resources needs to be addressed (Al Murshidi 2020). Additionally, the use of technology in STEM education is needed, but it requires a goal-oriented and cross-disciplinary approach (Dickson, Fidalgo & Cairns 2019). In terms of curriculum, STEM education needs to include more authentic entrepreneurial experiences in order to develop the skills that students need for their future careers (Eltanahy, Forawi & Mansour 2020). There is also a need to increase the recruitment of highly qualified STEM teachers (Alyammahi et al. 2016; Nichols & Kohn 2020) and provide professional development for STEM teachers (Al Quraan 2017). Regarding perceptions, Dickson, Fidalgo and Cairns (2019) highlighted that more STEM awareness is necessary to increase student interest in STEM and fueling this passion must start at a young age. According to the 2018 PISA results, girls scored higher than boys in science by 26 score points and in mathematics by nine score points. Albalooshi and May (2018) highlight that women need more encouragement and support to choose STEM fields.

The lack of STEM interest and persistence in the high school level continues into the university level. For instance, enrollment in business sectors comprise over 75% of student enrollment in the UAE even though STEM education will be a key qualification for future jobs (British Council 2018). In comparison, India and China are currently setting the pace for conferring STEM related degrees at 25% and 22% respectively (Vought 2018). The UAE is currently not at this level of producing STEM graduates. The need to improve the quality of education to prepare graduates to match the demands of the labor market is a rising concern (Wan-Husin et al. 2016). Higher education in the UAE needs support from the Triple Helix actors to adequately prepare students for future careers. The UAE leadership acknowledges that private sector participation needs to be increased to prepare students in STEM related subjects for the future job market (PWC 2019), indicating that the relationship between academia and industry need to be established (dem Moore, Chandran & Schubert 2018; Nichols & Kohn 2020).

Soomro (2019) highlights the need for the UAE to implement the framework of a STEM-based education. The Triple Helix model has been used to promote collaboration between the local and central government, community leaders and educators to improve opportunities and outcomes for students in STEM education and careers (Paige et al. 2016). Although the Triple Helix model is popular in the business sector, it is not commonly used in educational programmes with industry partners (Karmokar & Shekar 2018). There is a call for the Triple Helix actors in the UAE to take the opportunity to collaborate to develop STEM education in the Cycle 2 schools, Cycle 3 schools and the universities (Shaer, Zakzak & Shibl 2019). According to Salem (2017), the scope of the Triple Helix's impact extends to both the formal and informal learning environments.

1.3 Significance of the Study

This study has the potential to shift policymakers' focus as it increases awareness about the positive impact of the Triple Helix collaborations on STEM education programs and the need to include these partnerships in STEM education policies. The OECD (2015) observed that the UAE is working towards improving the quality of education while increasing institutional support and involvement. Educational reforms have been a method used by the government to respond to global technological advancements since the UAE leadership believes that human investment will power innovation (UAE National Committee on Sustainable Development Goals 2017; UAE Government 2015). To further invest in human capacity, the UAE government announced (2015) to be a "Year of Innovation" and the policy of the country shifted to reflect an economy which is innovation-based, diversified and knowledgeable (Delgado 2016). These three Triple Helix actors are viewed as the principal initiators for the economic development in the region by creating a knowledge-based economy through innovation (Guerrero, Cunningham & Urbano 2015; Sarpong et al. 2017). The Triple Helix model is influential because it has the potential to impact research knowledge exchange, develop the STEM program and establish policy recommendations (Todeva & Danson 2016). The ability for the Triple Helix model to contribute to knowledge production relies on the communications and partnerships that produce alliances and hybrid organizations (Etzkowitz & Zhou 2018). To ensure long-term growth, nations must innovate and adopt technologies which require investing in science. With the Triple Helix actors investing in coordination, new research advancements are made possible through long-term research and development collaborations. Both sciences and social sciences benefit from the intersection of two or more fields since the narrow focus of strengthening one discipline is expanded (The & Ahmed 2015). Improving the economy, through successful innovation, is the result of new knowledge being applied to productive activities. The environment that facilitates this phenomenon does not have an individual working in isolation (The & Ahmed 2015). Instead, it requires the Triple Helix model that allows for multiple agencies to work in accord with each other and expand each other's capabilities for innovation to be created and diffused to benefit a society's sustainable economic growth. As such, the Triple Helix agents must collaborate to improve STEM education by removing obstacles that prevent innovation to establish a knowledge-based economy.

Firstly, the study has the potential to provide educational reforms in STEM classrooms. For instance, the Triple Helix components can benefit STEM education programs by improving students' 21st century skills. The UAE Government (2015) highlights that 21st century skills are needed to empower innovative individuals. The Triple Helix components can benefit STEM education practices since more support is needed to teach the 21st century skills. For example, Fidalgo and Cairns (2019) mention that the implementation of technology, which is necessary for STEM learning, lacks consistency. Also, Quigley, Herro and Jamil (2017) recommend problem-based teaching since it develops higher processing skills and deep engagement. With the Triple Helix components, the STEM curriculum can be designed to include the necessary technological practice and critical thinking skills needed for future STEM careers. Additionally, the stakeholders' perspectives on the Triple Helix model can provide leaders/teachers with appropriate teaching plans and strategies that are effective to achieve STEM learning goals and better guide teachers to foster the 21st century skills among the students. Appropriate resources and funding can also be allocated to support students' entrepreneurial projects. Including the Triple Helix components has also been shown to improve learning for STEM students through collaboration between university and industry. For example, the Dubai Creative Clusters Authority established public-private partnerships between higher education and industry sectors to create a part-time work policy for students. At an early stage, students were exposed to real-world hands-on experiences that made it more likely that they would be hired for full-time employment after graduation (El Sholkamy 2018).

Secondly, the study can also contribute to increasing STEM awareness by highlighting that STEM is important for the future. It has been recognized that there is an important requirement for extensively skilled STEM employees worldwide, and this demand has been constantly increasing according to the estimates of the World Economic Forum (2018). Relatedly, the need for skilled STEM employees will continue to grow in the increasingly developed domains of the global market because the number of STEM employees is insufficient according to the requirement of current market trends. Globally, science educators are endeavoring to keep students interested and active in STEM (McDonald & Waite 2019). In the UAE, there is a prominent shortage of skilled workers in the STEM fields so new strategies are needed to fulfil the current market demands (Ecouncil.ae, n.d.). The need is further emphasized by the WEF (2018) as 75 million jobs could be displaced by 2022. The WEF (2017) also estimates that 47% of jobs in the UAE will be replaced by automation by 2030. It is important to address this issue so that future generations will be prepared for the changing labor market (Manyika, Chui & Miremadi 2017). Despite the future job losses due to technological advancements, new technology will also create 133 million new jobs (WEF 2018). To meet the unstable and unpredictable needs of the future workforce, STEM education reforms can lead to a productive and innovative economy (Figueroa et al. 2016).

The study has the potential to contribute to STEM education reform in the UAE by providing the beneficial elements of the Triple Helix model. Currently, there is no literature on the Triple Helix components benefiting STEM education and STEM careers in the UAE. In adding the Triple Helix components to the implementation of STEM education, there will be more potential to achieve the UAE's Vision 2030's goal to create a knowledge-based economy. It can improve the formal and informal STEM programs for middle and high school students as a preparation for STEM degrees and STEM careers.

1.4 Research Purpose & Questions

The main purpose of the study is to investigate the common themes related to the formal and informal STEM programs and stakeholders' perceptions and responses on formal and informal STEM education programs, STEM careers and the Triple Helix model in the UAE. These themes are related to international STEM integration models and focus on how the Triple Helix model can enhance STEM educational practices and policies to meet the UAE's Vision 2030.

Collecting the perspectives of stakeholders from different STEM education backgrounds and experiences helped to widen the researcher's scope of understanding of STEM education through high-quality feedback. Also, the perceptions of the stakeholders on STEM careers were collected to determine the state of the future STEM workforce. The

National Science Board (2015) stated that the STEM workforce ecosystem is complex, and it is difficult to assess the number of STEM jobs available today and those that will still exist in the future. It is also challenging to factor in the number of workers qualified for those positions. Stephens, Spraggon and Vammalle (2019) identified a skills gap that is diminishing the UAE's competitiveness, economic development and innovation capacity. In order to be competitive, students must be equipped with mindsets, knowledge and skills related to STEM (White & Shakibnia 2019). As White & Shakibnia (2019) mentioned, STEM education creates changes in aspects of education, work and community life, therefore, STEM education is integrated into daily life through its curriculum of solving real-world problems. Due to the impact of STEM education on the STEM attrition rate and the high need for future STEM careers, it is important to seek students' perceptions to improve the STEM pipeline, which refers to the STEM education pathway for students (Palmer, Burke & Aubusson 2017).

The study also focused on the Triple Helix model's impact on STEM education and providing support for STEM careers to fulfill the UAE's economic vision for the future. The study defines the Triple Helix model as the collaborative relationships between university, industry and government that promote regional innovation and economic development, which is a definition adopted in countries around the world (Cao et al. 2019). By using the Triple Helix model, the UAE can effectively pursue its Vision 2030 goals which highlight the important links between education, the future labour market and the goal to become a knowledge-based economy (Ashour 2020). To meet the UAE's goals for innovation, the collaborative efforts of university, industry and government in the Triple Helix model are influential. Universities play a role in creating a knowledge-based economy through academic research interactions with the other Triple Helix actors (Saad, Guermat

& Boutifour 2020). Innovative capacity is further supported by industry since partnerships increase private sector productivity (Rowland-Jones 2016). The government also develops the Triple Helix partnerships by supporting initiatives and regulations for research and development, simultaneously advancing education and the future workforce (Ankrah & Omar 2015; Committee on STEM Education 2018). By analysing the data, the influence of the Triple Helix collaborations on STEM education and STEM careers is investigated for the purpose of providing recommendations for STEM education policies. Utilising the Triple Helix partnerships can improve STEM education and STEM careers by developing social and economic growth that is in line with the UAE's vision. To attain the key outcomes of the study, this research will work to find the answers to the following questions:

RQ1: What are the common themes associated with the formal and informal STEM education programs to benefit the UAE?

RQ2: What are the perceptions of stakeholders on the formal and informal STEM education programs, STEM career choices and the Triple Helix components?

RQ3: What are the stakeholders' responses on the connections among the Triple Helix components with formal and informal STEM education programs and future STEM careers in the UAE?

1.5 Overview of the Research Study

STEM education will benefit the UAE by providing a means to achieve the country's Vision 2030. This is made possible through the elements of rigor and relevance added into the national educational curriculum that STEM education provides, along with the skills needed in the subject of science, technology, engineering and mathematics that opens doors for future careers. The study has the potential to advance STEM education to align with the nation's drive to achieve the goals of Vision 2030. STEM education focuses on teaching students science, technology, engineering and mathematics. STEM education can take place in the formal classroom setting and through informal experiences outside of the classroom. In the context of this research, STEM education programs include STEM learning experiences provided by the government schools, universities and industries.

It has been found that the Triple Helix model plays a critical role in maintaining a country's global competitiveness through the development of a knowledge-based economy (Wonglimpiyarat 2015). This researcher would like to pursue further study into the Triple Helix actors' capacity to influence STEM education and STEM careers and follow-up studies can be conducted in the future related to the Triple Helix model based upon the findings from this mixed-method research. STEM education programs can be assessed against the findings in this study to determine educational, opportunity and resource gaps that are present in current educational practices. This research will also allow school leaders, industry leaders and policy makers to determine the most appropriate partnerships and policies to allocate resources needed to improve the STEM pipeline. As a result, the study will play a role in expanding the ways in which the Triple Helix model can benefit the STEM education programs to facilitate pathways into STEM careers.

The Triple Helix model is relevant to discussions regarding STEM education in the UAE. The UAE aims to develop human capacity to promote business innovation, technology-based innovation and science-based innovation for socio-economic development (UAE Government 2015). Due to the high need of STEM workers for nationwide innovation, improving STEM education remains a high priority. Enhancing cooperation and knowledge exchange between the Triple Helix actors can stimulate development through coordination.

To address the UAE’s goal to create a knowledge-based economy, this study aims to identify the ways in which the three actors of the Triple Helix model can provide an integrated approach, along with the resources, to improve the integration of STEM education and benefit STEM careers. This has been accomplished through a mixed research design. The following review of literature in Chapter 2 highlighted the need for this type of study and discussed the literature review. In Chapter 3, the methodology is described in greater detail. Chapter 4 analyzed the results of the study and Chapter 5 contained the discussions, conclusions, implications, recommendations and limitations of the study.

1.6 Summary of Chapter1

Chapter one discussed the significance of having the Triple Helix components to support STEM education and STEM careers. Also, the need for clearly embedding 21st-century skills in STEM education was highlighted, as well as other opportunities for developing STEM education. The statement of the problem also indicated the gap in literature that gives rationale for the study, making it relevant and important to incorporate the Triple Helix components in STEM education. As a starting point, the researcher outlined the research questions and discussed the role of the Triple Helix components in addressing the STEM career gap of the UAE by promoting a knowledge-based economy. The research aimed to highlight how to improve STEM education and STEM careers to benefit the economic prosperity of the UAE.

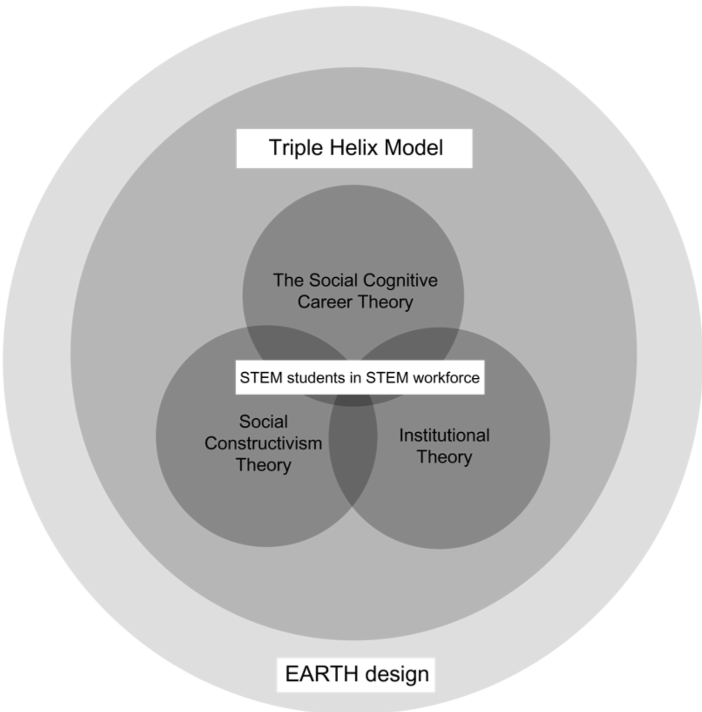
1.7 Structure of the Thesis

This study presents five key chapters: Introduction, Literature Review, Methodology, Data Analysis and Discussions and Recommendations. The current chapter is the introduction which includes the rationale, significance of the study, the problem statement, the purpose of the research study and the research questions. The next chapter includes detailed descriptions of the theoretical framework and the literature review. The theoretical framework describes the main theories included in the study: Triple Helix model, Social Cognitive Career Theory, Institutional Theory and Social Constructivism Theory. The literature review explained the importance of STEM education, STEM careers and the collaboration between university, industry and government to promote both. In chapter three, the methodology that the study used was explained through the research design, the study population, the sample, the research instrumentation, data collection, pilot study, validity and reliability and the ethical considerations processes. Chapter four discussed the data analysis used for each research question using tables and diagrams and quotations from the participants to add more clarity and depth. The results of every phase were analysed separately. The fifth chapter summarized the whole study and compared the results in the various stages of the study. Additionally, the discussions of the findings and the integration of results. The chapter concludes with the main recommendations and key limitations.

CHAPTER 2: Theoretical Framework & Literature Review

This study aimed to investigate formal and informal STEM education through the implementation of the Triple Helix model in the UAE. In this chapter, the theoretical frameworks and the literature review will be discussed. The following theories will be described: The Triple Helix model, Social Cognitive Career Theory, Institutional Theory, Social Constructivism Theory and the EARTH design. The literature review includes a discussion of the factors that impact stakeholders regarding STEM education, STEM careers and the Triple Helix model. Figure 2.1 demonstrates how the theories work together to benefit STEM education programs and STEM careers.

Figure 2.1: Integrated Theories Utilized in the Research



2.1 Theoretical Framework

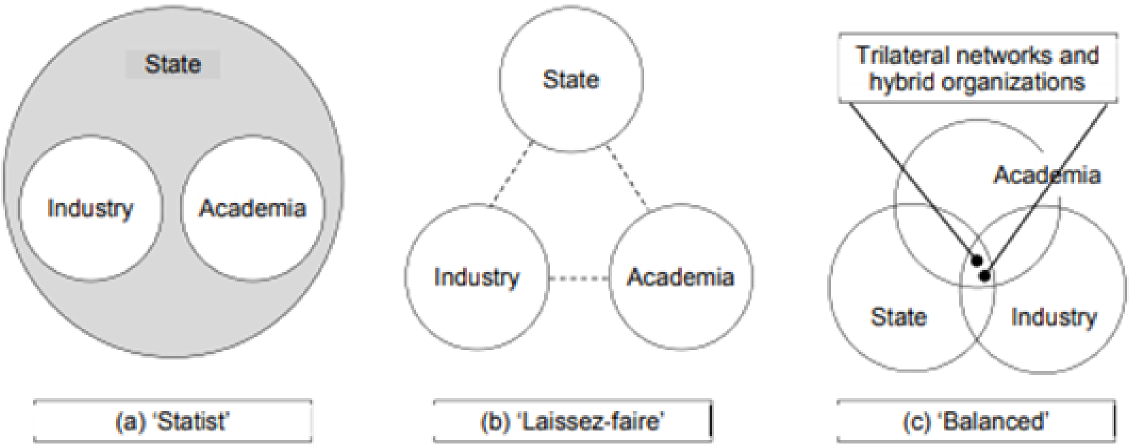
The following section will describe the five theories informing the study. The theories include: The Triple Helix model, the Social Cognitive Career Theory, the Institutional Theory, Social Constructivism Theory and the EARTH design.

2.1.1 Triple Helix Model

The Triple Helix model is the collaboration between government, industry and university as a way of improving the knowledge-based economy (Litchfield & Dempsey 2015; Mandrup & Jensen 2017). As knowledge continues to gain more significance, become an essential element for innovation and promote the creation and dissemination of technological and scientific knowledge from educational institutions, the model has an essential role to play in creating problem solvers and innovators in the coming years (Grover 2019).

The Triple Helix model is based on the core concept of the relationship formed between government, university and industry. The Triple Helix model was formed as the role of universities' impact on innovative economic development became more apparent. As universities continue to work in close collaboration with government and industry, new research-based knowledge is produced, spread and implemented (Etzkowitz & Zhou 2018). In the UAE, a knowledge-based economy is central to the UAE vision and increasing the number of STEM workers needs more collaboration among the Triple Helix entities.

There are different ways to understand the commercial research and the socio-economic development made possible by the Triple Helix model. Studies have evaluated stakeholders, barriers, impacts and benefits regarding the Triple Helix model (Etzkowitz & Leydesdorff 2000; Booyens 2011; Karmokar & Shekar 2018). The institutional link between government-university-industry is strengthened by government policies that promote entrepreneurship to develop regional economies. From the neo-institutional perspective, there are three main relationship structures between the three Triple Helix actors (Etzkowitz & Leydesdorff 2000); See Figure 2.2.



(Source: Etzkowitz & Leydesdorff 2000, p. 4)

Figure 2.2: Configurations for the Triple Helix Model (Etzkowitz & Leydesdorff 2000)

1. A statist configuration: governments play an important role in driving academia and industry, but limit its capacity for initiating developing innovative transformation, such as applied in China, Russia, Latin America and Eastern European countries (Etzkowitz & Leydesdorff 2000; Etzkowitz & Zhou 2018). Governments are necessary in the innovation process since they provide the means to coordinate, regulate, and fund projects and policies, but they need to collaborate with other institutions to create new and novel ideas (Etzkowitz 2018).
2. A laissez-faire configuration: this approach is identified as having limited collaboration between the Triple Helix actors. For instance, government intervention in the economy is minimal, such as in the USA and some other western regions. In this regard, the institutions are separated. Industry plays a larger role and the other two Triple Helix actors support the system with clearly identified and separate roles for business innovation. All three are key sources for human capital by building skills, with governments clearly acting as socio-economic regulators. During a

market crisis, the government increases its role by taking control through the support it provides universities and industries. Each institution works independently (Etzkowitz & Leydesdorff 2000; Etzkowitz & Zhou 2018).

3. A balanced configuration: this structure leads to the transition to a knowledge-based society in which all three or two Triple Helix actors are working together. Joint initiatives center on missions to benefit the institutions themselves while improving society. By resolving conflicts of interest, shared interests create advantages that benefit more than one sphere. For instance, industries are able to create economic improvements and universities contribute through research and teaching (Etzkowitz & Leydesdorff 2000; Etzkowitz & Zhou 2018).

The balanced configuration has been labelled as the most suitable environment for increasing innovative development. It is beneficial for the following reasons: it develops creative synergies, increases interaction between institutions and provides new learning opportunities for students. The balanced configuration helps to correct the inadequate performances of the Triple Helix actors (Etzkowitz 2002; 2008). The collaborative relationship between the three Triple Helix entities begins a creative process that can enhance education through innovation in the form of new technologies and businesses (Etzkowitz & Leydesdorff 1998). Additionally, organizational creativity is also made possible by the removal of technological or sectoral boundaries that separate the institutions, allowing employees to contribute to different lines of work. New guidelines are also produced and emphasize business collaboration amongst the Triple Helix elements to enhance regional developments (Pugh 2017). Just as it promotes organizational creativity, the Triple Helix model can also promote innovation in STEM education (Etzkowitz & Zhou 2018).

The Triple Helix model is supported by policymakers because its simplicity makes it easier to implement policies to improve coherence between different institutions, which can improve the process of innovation (Rodrigues & Melo 2013). In recent years, we have seen a change from an individual focus where sources of innovation were restricted to one institutional sphere, such as industrial product development, governmental policy making, or knowledge development in academics. Now, the focus is on how the three spheres proposed by the Triple Helix model are interrelated and interact to create a source of new innovative designs and social interactions (Ranga & Etzkowitz 2013). The change accounts for the restructuring of institutions as sources of innovation development. Additionally, it allows institutions to rethink their capacity to promote innovation. The UAE's Vision 2030 focuses on advancing innovation and entrepreneurship in science and technology (Shaer, Zakzak & Shibl 2019), highlighting the importance of STEM education and its focus on 21st century skills (Grover 2019), which can be facilitated by the Triple Helix model. The collaboration between the Triple Helix actors can influence students to pursue a job in STEM careers by increasing student exposure to STEM subjects in an engaging format through real-world application. As a result, with the partnership of the Triple Helix components, students are motivated to seek future STEM jobs that promote innovation (Karmokar & Shekar 2018). Increased communication between the UAE's Triple Helix actors can improve educational policies by incorporating feedback from stakeholders. Through meaningful collaboration, STEM curriculum can implement strategies that better prepare and motivate students to meet the industry needs of the future.

2.1.2 The Social Cognitive Career Theory

The Social Cognitive Career Theory (SCCT) is based on Bandura's general Social Cognitive Theory and was developed by Lent, Brown and Hackett in 1994 (Lent, Brown & Hackett 2002). SCCT relies on socio-cognitive constructs to explain career development

(Burnette et al. 2019) and central to SCCT is the assessment of how academic and career choices emerge and translate into actions (Schultz & Schultz 2016). It is a relatively new theory that attempts to explain the following processes: (1) the development of basic academic and career interests, (2) the decision making behind educational and career choices, and (3) obtaining academic and career success (Hackett 2002). These processes are influenced by the interplay between the personal, environment and behavioral factors (Gainor & Lent 1998; Gloria & Hird 1999). These factors can include: gender, race, social support, and both perceived and systemic career obstacles (Bounds 2017). Self-efficacy, outcome expectations, and goals are linked variables that create the foundation of SCCT (Lent et al. 2017; Hackett 2002), and they are the most pertinent to this study.

Self-efficacy remains the primary focus in career literature (Dorph et al. 2018; Hammoud et al. 2019; Lent et al. 2017; Musso et al. 2019) Self-efficacy refers to one's personal beliefs about his or her abilities to perform particular behaviors or take courses of action (Lent, Hackett & Brown 2008). Lent, Brown & Hackett (2002) posits that self-efficacy in a certain activity increases the likelihood of the person becoming more interested in it, more likely to choose to pursue it and to perform better at it, as long as they also have necessary skills and environmental support to pursue the activity. According to Bandura (1986), self-efficacy also includes the ability to identify and organize one's actions to attain their objectives. From the SCCT perspective, self-efficacy is not identified as fixed and includes dynamic elements. This is due to the influence of the external environment on individual behaviors. Additionally, depending on the behavior required in different occupational domains, people vary in their self-efficacy (Lent, Brown & Hackett 2002). For example, confidence in accomplishing tasks in a science field might not transfer to a sales field (Leong 2008). Self-efficacy also includes values and beliefs that are acquired from four sources: personal performance achievements, learning experiences, social presence and psychological influences (Fong et al. 2019; Lent, Brown & Hackett 2002). Self-efficacy can play a key role in positive youth development because it is a component of a young person's self-evaluation, which in turn influences what they can achieve and become (Burger, Mortimer & Johnson 2020). From a young age, STEM education needs to prioritize increasing students' 21st century skills in order to develop their confidence and increase the likelihood of pursuing a STEM career.

Outcome expectations is the second foundational component in SCCT and it refers to what an individual believes the consequences or outcomes will be after performing particular behaviors. How much persistence and effort an individual will exert in an activity and the choices they make about the activity is influenced by outcome expectations and self-efficacy. For instance, if activity involvement leads to a positive and valued outcome, such as social and self-approval or tangible rewards, then people are more likely to engage in the activity (Leong 2008). STEM programs in the UAE need to consider rewards systems to increase students' intrinsic and extrinsic motivation to attract and retain students in STEM career paths.

The third foundational component in SCCT is individual goals which can be defined as an individual recognizing engagement in a specific activity to attain a specific level of performance (Schultz & Schultz 2016). The process of an individual organizing and developing specific goals supports and sustains their long-term behavior without external influences. Individual goals reveal a complicated mechanism in which an individual taps into both personal interests and self-motivation (Lent, Brown & Hackett 2002; Leong 2008). Goals are linked with self-efficacy and outcome expectations because goals are aligned with one's capabilities and the results of taking a specific course of action (Leong 2008). As a result, successful goal attainment can lead to the confirmation of self-efficacy beliefs and outcome expectations (Leong 2008). UAE students need to be supported and nourished to build investment in the benefits of pursuing STEM careers to achieve the country's vision.

According to Lent et al. (2017), the SCCT Theory is a promising model for predicting interests and intents for pursuing academic options and careers. The SCCT Theory allows researchers to make use of measures of self-efficacy, outcome expectations, and personal backgrounds and inputs, as well as contextual support and/or hindrances for explaining the logic behind students' career/academic choice (Lent 2005; Lent et al. 2008). Research has made use of this theory as a predictive model of interest in the STEM fields, which have largely been at the cycle 2, cycle 3 and university levels (Lent 2005; Lent et al. 2008).

This research study incorporated student surveys to assess SCCT components, such as self-efficacy, outcome expectations and environmental support to build a better understanding to guide student transition to STEM careers. SCCT was foundational for this research because it emphasized the social and motivational factors that influence career orientation and academic performance (Nugent et al. 2015).

2.1.3 Institutional Theory

New institutionalism refocuses political science through a systemic analysis of institutional impact on society (Peters 2019) by identifying the norms, practices and relationships that influence patterns of political behavior and policy making (Cairney 2020). Peters (2019) claims that the internal differentiation in new institutionalism provides researchers with the ability to explore the influence of institutional structure more broadly on the conduct of government and public policies. In terms of structure and agency, it is the impact of institutions that precede action (Lecours 2005).

There are a few key indicators that distinguish between the "old" and "new" institutionalism. First, new institutionalism is seen as a response to neoclassical and behaviorism approaches. Beginning during the 1980s, the importance of public sector institutions was revisited to explain not only policy and governance, but also individual-level behavior (Peters 2019). This was a move away from the theoretical approaches dominating political science in the US during the post-World War II period that promoted individuals acting autonomously as individuals without the constraints of institutions (Peters 2019). Instead of this individualistic approach to the discipline, more weight was put into the ability for institutions to shape action and influence political processes (Lecours 2005). Second, there is a marked shift from the focus on formal institutions to informal institutions (Lang 2018). Peters (2019) describes institutions as structural features of society that involve groups of individuals in patterned and predictable interactions. The institutional structures can be formal, such as a legal framework or an agency, or informal, such as a set of shared norms or a network of organizations (Peters 2019). Features of institutions include: stability, effect on individual behavior and a sense of shared values among members of the institution (Peters 2019). Third, new institutionalists support the belief that institutions pre-structure agency by guiding actors', such as individuals and organizations, behavior (Lang 2018).

Alvesson and Spicer (2019) assert that New-Institutional Theory is an important school of thought regarding organizational behavior studies. Vogel (2012) traces how the New-Institutional Theory developed in the 1980s as a small school of thought, increasing importance in the 1990s and growing exponentially from the 2000s. Since institutions can have meaningful outcomes, it is important to consider how they change (Farrell 2018). It is important to note that a singular definition for "institution" and "new institutionalism" do not exist and there are many approaches to the concept (Cairney 2020). In their anthropological analysis, Sahlins and Ortner argue that reasons for change in society are due to the constant reproduction of structures (Wegerich 2005). This means that over time, established formal and informal institutions can change. One method of explaining these changes is the Rawlsian veil of ignorance. According to this approach, individuals and the community only have partial information regarding the ‘world’ and the interrelationships between the subjects and objects in the world. Institutions are now established by individuals and communities with incomplete information since not all parameters are known. The definition of the position of the individual and the community according to the new information about the objects and subjects in the world that is being discovered (Wegerich 2005). New information can lead to changes such as: a new self-definition, new practices or technical changes and communication. As a result, new institutions can be made or the old formal and informal institutions can be manifested. It is important to note that new information is not the only cause of change. Within each structure, all individuals have a variety of choices in their responses (Wegerich 2005). Such decisions can lead to altering the settings which can trigger new self-definitions and new definitions of the social environment. With a new self-definition, new practices can result that can change informal and formal structures (Wegerich 2005). Therefore, the combinations of the reproduction of structures and the present conditions might lead to changes. Additionally, changes are not always planned. As a result, additions, caused by mistakes, can occur during the reproduction of a structure. However, the impact of new information, choices and mistakes as factors contributing to structural changes is still questionable (Wegerich 2005).

Schmidt (2010) identifies four approaches to New-Institutional Theory which include rational choice institutionalism, historical institutionalism, sociological institutionalism and discursive institutionalism. Rational choice institutionalism assumes that the actors act logically, but to create order, the rationality is limited because institutions create rules (Williamson 1996). In this sense, institutions can be viewed as rules that create patterns of behavior that the actors have agreed to follow (Farrell 2018) by providing incentives or constraints (Cairney 2020). Institutions communicate social preferences by providing the “context” for individuals to consider the consequences of their actions (Cairney 2020). Historical institutionalism focuses on how past events and decisions influenced the formation of institutions that impact current practices. This approach views the nature of institutions on a wide scale by including both formal and informal rules and shows how institutions can both constrain and be resistant to change themselves (Mahone & Thelen 2010). Cairney (2020) highlights how institutions prioritize stable development to decrease costs that limits their change in infrastructure. Institutions are simultaneously considered as both processes that change over time as well as structures that provide stable political and social behavior through social organization (Farrell 2018). Sociological institutionalism highlights how culture impacts the nature of institutions as well as the ways in which they affect the behavior of the actors (Scott 1995). Unlike the other investigative approaches to institutionalism, it is more interested in articulating the continuity of institutions through external factors rather than transformation (Farrell 2018). Its focus is on the internal processes of institutions, their relationships with other parallel institutions, and its general existence. There is a marked shift away from the utilitarian perspective of the rational and historical approach and towards the ceremonial and symbolic (Friel 2017). The fourth school of institutionalism, as proposed by is discursive institutionalism which emphasizes how discourse shapes both political outcomes and institutional change (Schmidt 2010). Ideas are generated and legitimized through the interactive process of communication and the role of the institution is to establish the structure that creates the scope of acceptable ideas in the interaction (Friel 2017).

Institutional theories emphasize the stability of structures and the obstacles to change (Poppen & 2018). Scott et al. (2000) note how human behavior is constrained or driven by institutions, underscoring that institutional change comes before behavioral change. This shows that innovation works in contrast to institutionalization (Lammers & Garcia 2017). However, Foss and Gibson (2015) identify universities and its entrepreneurial capacity to prompt institutional change. Leca, Battilana and Boxenbaum (2008) define institutional entrepreneurs as active participants in the initiation of change in the institutional system. In an institutional system, organizational and individual actors, possibly spanning various organizational fields, are influenced by their own logics, but also initiate a change in logics through interaction (Cai & Liu 2020). Accordingly, Etzkowitz and Leydesdorff (1997) perceive an innovation system as an institutional system since it comprises multiple organizational fields. The Triple Helix model is an innovation system since its dynamic interactions between government, university and industry makes innovation, entrepreneurship and economic growth possible in the knowledge-based society (Cai & Liu 2020).

In order for the Institutional Theory to support the economy, cooperation between the actors is key (Guerrero et al. 2016). According to Scott (2014), economic relations need a regulatory framework which allows them to interact in the market; it is there that institutions act by establishing certain limits, whether formal or informal, to regulate the economic negotiations in an imperfect market. Therefore, the interaction between political and economic organizations and institutions results in the improved economic performance of a country and forms the mechanisms to carry out its financial development. The knowledge-based economy requires constant change but creating change at the institutional level is challenging due to the complex social arrangements involving many different actors. However, it is through the institutions' contracts, authority and universalistic rules that commission organizational structures and processes that creates change in society (Thornton & Ocasio 2008). Collaboration between institutions combines their strengths to create innovation in STEM education to develop local human capacity for the UAE to compete globally. To change the individual, we must change institutions first. Changing stakeholders' attitudes and behaviors towards STEM education requires changing institutional norms.

2.1.4 Social Constructivism Theory

Social Constructivism Theory allows students to develop their learning through the social process of observing, interacting and experimenting (Elliott et al. 2000). Students construct their learning, at an early age, based on the environment they were born into and the personal experience which goes along with it. Their interaction with friends and family plays a big role in constructing a sense of knowledge, making emotion and opinion relevant to everyone's learning process (McDonnell & Minton 2017). Hence, when becoming a part of a new experience, individuals would integrate their newly attained knowledge to the knowledge they previously acquired; this helps students create a new perspective and understanding while extending their learning process. The theory was proposed by Lev Vygotsky and focuses on the development of reality and individual world perspectives of a child (Davies & Fung 2017). Cognitive development is produced by the process of internalizing social interaction with materials provided by the environment, and the process is being built from the outside in (Wertsch 1997). From birth, a baby becomes part of a community marked by specific habits, gestures, languages and traditions that guide the direction of child development (Radloff & Guzey 2016). Social Constructivism Theory centers on the premise that learning and development are products of social interactions and there is a focus on psychosocial interactivity as a key process in education (Radloff & Guzey 2016; Resnick, Asterhan & Clarke 2015). According to Vygotsky, education is not static and waiting for the intellectual development of the child. Rather, its function is to move the student forward, for the more he/she learns, the more he/she develops mentally.

Accordingly, children carry the potential to learn, so the background knowledge of the individual must be taken into account during the teaching-learning process (Wright 2018).

In the zone of proximal development (ZPD), a theory proposed by Vygotsky, students have the tendency to become individual learners, however there is a limit to how much a person can learn. To increase the potential to gain more knowledge, there must exist a sense of cooperation and engagement with adults or peers. The encounter and communication with other individuals within a social environment will promote more learning and build up new skills and mastery. The guidance and encouragement given to learners and students will enable them to master and progress towards reaching their potential levels of learning. Students that are put in groups to discuss, collaborate and interact together, use each other's skills to complete tasks. Knowledge will be transferred and achieved in this process (Vygotsky 1978).

Therefore, schools should promote teaching as a means to increase cognitive ability by striving to reach more fully matured stages of student development (Brunstein et al. 2015; Kattari 2015). Schools should start at the child's actual level of development and through instruction, the teacher can create learning experiences to advance student learning that would not occur spontaneously. Learning then becomes about working towards long-term potentialities and processes, with learning preceding development. With STEM education, teachers are able to prepare students for the future by recognizing their current ability levels and push them towards the ZPD.

STEM education moves students to their next level of understanding through scaffolding (Admawati, Jumadi & Nursyahidah 2018) and collaboration (Achzab, Budiyanto & Budianto 2018). As social constructivist teachers, the students' learning experiences can become more personalized by addressing the cognitive domain and affective domain. For the cognitive domain, social constructivist teachers can include scaffolds into the STEM curriculum through feedback and design tasks that are designed to be appropriately challenging for students to push their learning (Admawati, Jumadi & Nursyahidah 2018). For the affective domain, social constructivist teachers can also increase student motivation by highlighting that students are co-constructors of their knowledge and help them to develop their own learning agendas (Admawati, Jumadi & Nursyahidah 2018). Additionally, collaborative learning environments can be facilitated to enable students to create new knowledge (Bada & Bada & Olusegun 2015) by supporting reflective and experiential processes (Achzab, Budiyanto & Budianto 2018). According to Ah-Nam and Osman (2017), students would only benefit from social interactions if information is presented outside of traditional means. Accordingly, active student-centered learning in STEM uses real-world problem- solving and experiments (Admawati, Jumadi & Nursyahidah 2018), during which students must confront their prior knowledge in the context of the new learning situation. Students are able to co-construct knowledge as they share the experience of processing new information through investigation (Kelley & Knowles 2016). This means that students' individual understanding is changed as they produce new knowledge and form new meaning based upon these experiences (Bada & Olusegun 2015). Interaction between individuals is pivotal to Social Constructivism Theory because it is how knowledge is formed. Mediators, such as the teacher or peers, help the student to achieve a development stage that he or she cannot yet reach alone (Williams 2017).

Social Constructivism Theory emphasizes that learning is situated socially and that new knowledge is formed through interactions with (McKinley 2015). Driver et al. (1994) highlight that scientific knowledge is socially constructed. The social constructivist approach is seen through the application of Project-Based Learning (PBL) in STEM education programs because group work leads to more meaningful learning (Wulan & Retnowati 2019). Collaboration is one of the 4Cs (Four Cs) of 21st century skills, which also include creativity, critical thinking and communication (Achzab, Budiyanto & Budianto 2018). According to Lapek (2018), the PBL approach is best suited for teaching 21st century skills. When students work with their peers to solve real world problems posed by the PBL approach, they practice their collaboration and communication skills. Discussions in PBL groups can also aid in processing new information and activate prior knowledge (Schmidt et al. 1989). Students' creativity is developed during the learning process by the student-led research that results in the creation of a product that uses different disciplines together (Samsudin et al. 2020). Additionally, students' critical thinking is fostered during learning that includes hands-on applications (Ring et al. 2017) and emphasizes the students' real-life experiences (Kelley & Knowles 2016), which builds on the student's prior knowledge, interests and identity (Bell, Morrison & Debarger 2015). Critical thinking skills are also boosted by STEM's emphasis on self-learning (Samsudin et al. 2020) and the scientific investigations that are student driven (Lazonder & Harmsen 2016; Pedaste et al. 2015). Patel (2019) underscores that students who have the 21st century skills that equip them with the capabilities to solve complex real-world problems will be better prepared for the future workforce.

2.1.5 EARTH Design

The EARTH design framework is created by uniting the theories of Educational Action Research and the Triple Helix components (Mandrup & Jensen 2017). Education is moving towards an entrepreneurship model that sharpens student creativity and critical thinking skills by designing learning experiences that require students to create innovative solutions that are based on their own knowledge (Shattock 2009). Guerrero et al. (2016) highlight that supporting entrepreneurial initiatives can lead to both social and economic development, so it is a worthwhile endeavor for communities to pursue. However, these advantageous entrepreneurial programs need support, and Scharmer and Käufer (2000) indicate that action research will be the key because new collaborations between internal and external partners can result in community action, research consortiums and strategic partnerships. With the theoretical synthesis of Educational Action Research and the Triple Helix model, the means to research and construct educational designs that are more relevant to support student learning is made possible through the involvement of collaborative actors from various sectors (D'Este & Perkmann 2011; Etzkowitz 2014). More specifically, through the collaboration of insider actors such as stakeholders in the schools and outsider actors from Triple Helix components, real-world innovation and entrepreneurship learning experiences can be designed to benefit STEM education (Mandrup & Jensen 2017). Having a solid association among all individuals from the Triple Helix model and STEM education will prompt a more grounded scaffold that will make students ready to select a career in a STEM field.

Mertler (2019) points out that traditional educational research, in comparison to Educational Action Research in EARTH design, creates a barrier between research and practice, as well as theory and action. This is due to the fact that there is an emphasis on the researcher as an outsider who is unbiased and objective (Mertler & Charles 2014). It is typically university-based researchers, who are outside of the context being studied, carrying out investigations at school settings to improve the quality of education by developing universal theories (Efron & Ravid 2013). From the traditional educational research perspective, educational innovation is hierarchical and planned in a top-down process. The outside experts provide knowledge and research findings for teachers and other school practitioners to consume and implement in their classroom (Efron & Ravid 2013).

In comparison, action research takes on a more subjective perspective by placing value and validity in the school practitioners' unique experiences and familiarity with their own particular setting (Efron & Ravid 2013). Practitioners gain insight into their students' worlds, and the diversity of students make it difficult to implement the generalized principles and universal theories created by unbiased researchers (Efron & Ravid 2013). In action research, the boundaries between practice and theory are blurred as teachers and other school personnel become researchers and study their own practice within their own distinct classrooms and schools (Efron & Ravid 2013). The benefits of consolidating the jobs of teacher and researcher through action research includes: empowering advancement, demographic strengthening, social change and professional improvement (Sexton & Lu 2009; Somekh & Zeichner 2009; Yeager & Walton 2011; Greenwood 2012; Townsend & Thomson 2015). As the researchers are insiders who are familiar and directly involved with the context, educational changes take on a more democratic bottom-up process, spearheaded by self-directed and knowledge-generating professionals (McNiff 2011). The action research cycle adheres to the following structure: posing questions, gathering data, reflection and deciding on a course of action (Ferrance 2000). An essential component of Educational Action Research is reflection. Some reflections will focus on actions taken, while others reflect on procedures and communications (Clegg 2000; Staniforth & Harland 2003). The literature on Educational Action Research tends to concentrate on reflections on practice, learning and expert improvement (Clegg 2000; Goodnough 2003; Staniforth & Harland 2003; Taylor & Pettit 2007; Elliott 2015).

The collaboration between the Triple Helix actors (government, university and industry) is dependent on the ability to freely organize based on bottom-up and top-down initiatives (Etzkowitz 2014; Etzkowitz & Dzisah 2013). There is an assumed equality in relations between the actors as the Triple Helix model relies on mutual dependency

(Etzkowitz & Leydesdorff 2000). The systemic mutuality develops from the integrated relationships and enables the change to a knowledge-base-society (Mandrup & Jensen 2017). According to Lee and Ngo (2011), human capital and intellectual resources have been elevated as the elements creating the foundation for collaboration and innovation. As a result, educational stakeholders, with their involvement through Educational Action Research, can benefit from taking a part in the decision making to improve STEM education policies.

The shared principles between the Education Action Research and the Triple Helix model combine to develop the EARTH design (Mandrup & Jensen 2017). According to Mandrup and Jensen (2017), the EARTH design serves as a bridge between action as knowledge-generation and collaboration across different contexts to develop new ideas, or solutions. Additional traits of the EARTH design include correspondence, consensus-making, volunteerism, uniformity, co-creation and joint effort (Mandrup & Jensen 2017). These elements help to support student learning, and this is made possible by the diversity of actors present in EARTH design that bolster dynamic substitution, wherein the roles of the Triple Helix actors become interchangeable. For instance, entrepreneurs take on a teacher's role as they impart their real-world experience (Mandrup & Jensen 2017). Additionally, Ranga and Etzkowitz (2013) propose that industry can also play the role of the university in developing solutions for education and training. Hence, the beneficial system can be designed to develop creative exercises and increase the academic achievement of the students, while simultaneously establishing organizational advancement and educational research. This structure will likewise give grounds to critical development ventures and plans through the complementary relationships formed amongst various partners such as associates, specialists, students and teachers (Ribeiro, Uechi & Plonski 2018).

The motivation behind EARTH design is to build associations among actors at different sectoral levels from the Triple Helix model, which are effectively engaged with creative learning (Mandrup & Jensen 2017). The theory evolved from Kolb’s "Learning Cycle”, a four-phase cycle of experiential learning consisting of (1) concrete experience, (2) reflective observation, (3) abstract conceptualisation and (4) active experimentation (Kolb 2014; Vince 1998). The first step requires experimentation from the Triple Helix actors to create innovative learning activities for students. The second step involves joint reflective observations between the Triple Helix actors and the third step reinforces Triple Helix member collaboration to support student learning. Lastly, the fourth step takes new understandings and creates actions to refine or revise educational practices. The dynamic educational inquiry is a constant cycle of experiential learning inside the EARTH design until the process is finished, which combines the experimentation of the Triple Helix actor relationships with general research (Mandrup & Jensen 2017). A key to this strategy is the choice of sectoral actors that are relied upon to add to the students' learning, skills, thought advancement and chances of creative joint efforts (Mandrup & Jensen 2017).

In the educational design of EARTH design, Triple Helix actors from different sectors can help to design curriculums that support student innovation (Mandrup & Jensen 2017). Learning cycles within the EARTH design can substitute, add and exclude key actors depending on learning goals (Mandrup & Jensen 2017). This framework benefits STEM education because student experience of ‘real world’ innovation and entrepreneurship are increased as Triple Helix actors can take a larger role in the educational system, engaging students with a diversity of external settings. STEM education can be supported by the collaboration between educational stakeholders and external Triple Helix actors to give students more resources to participate as creators in a knowledge-based-society, developing their confidence to live in a complex and changing world that is increasingly in need of STEM professionals (Shattock 2009).

The EARTH design connects the Institutional Theory, Triple Helix model, Social Constructivism Theory and the Social Cognitive Career Theory by emphasizing the necessary collaboration between internal and external stakeholders in order to improve the career pathway for students into STEM fields. Educational Action Research practitioners involve school faculty members who employ research methods to create practical solutions to gaps that they diagnose through their own observations and experiences. With this insider knowledge, collaboration and partnerships with external actors are needed to implement the educational reforms needed to prepare students to meet the new demands for STEM careers in the future workforce. Institutional Theory highlights that behavioral change requires collective effort from both inside and outside actors. Accordingly, outside actors, such as the Triple Helix members, are needed to improve STEM education programs. One aspect of STEM education that can benefit from these collaborations include increasing support for STEM learning that aligns with the Social Constructivism Theory to build 21st century skills. Also, the added support from the external Triple Helix actors can provide resources for students that align with the Social Cognitive Career Theory to promote STEM careers. The EARTH design focuses the efforts of the Triple Helix actors on STEM education, and the new knowledge and partnerships that improves all internal and external stakeholders involved can empower students to select a STEM career pathway.

2.2 Literature Review

This section provides a discussion of STEM education reforms to meet future needs and aligning STEM education and careers to benefit the future workforce. Additionally, a discussion of how the Triple Helix Model can play a role to benefit STEM education and STEM careers will be included.

It is important to first build an understanding of the STEM education program and how it is relevant to education today to understand how the Triple Helix model can benefit it. The goal of STEM is to channel the knowledge that is separated in four educational disciplines. STEM is the acronym used to designate the subjects of Science, Technology, Engineering and Mathematics (Berland 2013). Behind these four letters is an innovative concept of education that is changing the way students learn around the world. Chemistry, physics and biology are the dominant branches of sciences that are studied. Technology is the means of creating products, and engineering provides the application of knowledge into a concrete problem-solving form. Lastly, math provides the necessary skills to solve the practical and relevant problems provided. This interdisciplinary educational curriculum makes learning relevant to the students (Stubbs et al. 2018). The skills developed in these four disciplines are necessary to produce economic prosperity through future innovation.

The STEM education program originated from the teaching of science, technology, engineering and mathematics during the space race (Stubbs et al. 2018). As a result, educational policies that focused on product and technology development began to be established in applied knowledge first in the US and eventually in other countries around the world. In the 1970s, during STEM’s early stages, teaching was practically based on proving activities. This practice entailed going to a laboratory to prove scientific concepts such as learning how to measure gravity or how to calculate the acceleration of a metal ball. With the development of new technologies over the years, STEM has moved from proving scientific concepts to a more maker culture by employing hands-on activities that require effective projects. Our current era of ubiquitous technology has yielded educational advancements. For example, the emergence of 3D printers and laser cutters enables greater innovation by opening up more possibilities for students. Previously, students were encouraged to come up with solutions without access to adequate resources to build and construct their projects (Corbett & Hill 2015). Today, they can come up with an idea, and with the help of these new technologies, get them off the ground completely. Additionally, a research study conducted by Christensen, Knezek, and Tyler-Wood (2015) revealed that varying kinds of hands-on STEM related activities that required active learning and required designing solutions relevant to the real world can result in increasing positive interest in STEM subjects and careers. The future of education is STEM because it prepares students for upcoming technological innovation.

With the creative economy gaining increasing importance in the 21st century, STEM's emphasis on a multidisciplinary approach to education will benefit students (Connor, Karmokar & Whittington 2015; Oner et al. 2016). The goal of STEM is to drive innovation through design by encouraging the teaching of science, technology, engineering and maths in school. Many institutions have already adopted the new acronym, but the issue goes beyond classification (Hill, Corbett & St. Rose 2018). The important factor is that in everyday life, in working with teachers and in school projects, all areas can be incorporated. Incorporating a unified STEM approach to learning in the UAE will better prepare students since global challenges require an integrative and interdisciplinary problem-solving strategy. The future is rapidly changing and student learning needs to adapt accordingly, leaving room for the Triple Helix model to be part of STEM education programs.

2.2.1 STEM Education Reform for the Future Needs

This section provides a discussion of the STEM education program and 21st century skills. STEM education is on the agenda of many countries as a STEM-oriented workforce is necessary for innovation, emphasizing its social, economic and political impact (DeCoito 2016; Let's Talk Science 2017). Cedefop (2017) notes that across the European Union, the top five shortages in skilled occupations are STEM professionals. Between 2013 to 2025, this growth is expected to persist (Milner-Bolotin & Marotto 2018). The National Science Board (NSB) (2019) asserts that increasing STEM-capacity boosts economic activity since science and engineering careers are necessary to support the future economy. The core purpose of STEM education is to increase an individuals' skills to the level that matches the changing demands of the workforce (Litchfield & Dempsey 2015; Petersen et al. 2018). The US National Academy of Science (NAS) defined these skills as providing an in-depth understanding for transferring knowledge among various disciplines (Taylor 2018). In addition, Al Sawaleh et al. (2017) highlighted that a 21st century education is a vital element for providing an interlinked curriculum that is personalized, flexible, student oriented and relevant to every participant. All these skills are evaluated in a collaborative teaching environment prioritizing student support (Posner et al. 2016). The competencies and character qualities gained from a STEM education can benefit Emirati students by ensuring that they obtain a well-rounded education that fosters adaptability, allowing them to survive and thrive in the future workforce.

Relatedly, Mobley (2015) defines STEM education as a program developed for resolving real life issues with creative links to different disciplines that improves and contributes to the attainment of basic skills. Additionally, STEM education promotes critical thinking while developing problem solving skills in which creativity is promoted (Asunda & Mativo 2016; Education Council 2015a; Kasza & Slater 2017). Critical thinking happens during the process of finding the solution to any problem, thereby solving the issue (Cropley 2015; Mutakinati et al. 2018). To improve the students' critical thinking skills, Ardianti et al. (2020) found that incorporating technology in STEM learning for middle school students was effective in comparison to a conventional teaching approach. Additionally, the Project Based Learning approach to teaching STEM has been shown to advance middle school students' critical thinking skills (Mutakinati et al. 2018). By investing in STEM education, the UAE can reap the benefits of new generations of problem solvers and critical thinkers to create innovative solutions so that they remain competitive in the global economy.

In STEM classes, students are driven to acquire and use the diverse knowledge they need from different subjects within a project, which in turn leads to better preparation for the job market of the future as it will require an interdisciplinary approach to problem solving. For example, technology-related projects such as robotics involve complex issues that require more than just engineering competency (Colter 2018). In addition to students applying what they have learned in class when confronted with real-world issues, they must also rationalize their approach and develop a more analytical view that acknowledges their place in the wider community (Colucci-Gray et al. 2019). As students are encouraged to suggest solid solutions based on facts and evidence, they are cultivating a critical sense through the stimulation of research and reflection. During this process, their questioning and inquiry skills improve as they experiment and reflect on their results by designing more appropriate solutions to the proposed situations (Kelley & Knowles 2016). Furthermore, creativity is explored through the use of technological tools and the need to discover effective ways to solve problems. Leadership skills are also honed due to the greater autonomy that students have during the lessons (Asunda & Mativo 2016; Kasza & Slater 2017; Kelley & Knowles 2016). Through STEM's project-based learning approach, Emirati students can develop future skills for careers that they want to pursue. They will be exposed to more meaningful and deep learning experience by conducting research, investigating multiple perspectives, connecting ideas and collaborating with others in order to solve a problem.

2.2.1.1 Better outcomes and incentives

This section provides a discussion of professional development for STEM teachers, technology in the STEM classrooms, the STEM learning environment and 21st century skills.

The STEM education program is seen as one of the most recent influential educational reforms (Gottlieb 2018). It is an integrated curriculum that connects science, technology, engineering and mathematics (Xie, Fang & Shauman 2015). STEM is focused on integrating these areas by applying teaching methods to develop skills related to these fields (English 2016). As a result, the approaches and methods of investigation reflect the scientific principles combined with the utilization of essential mathematical concepts as a core component. Vought (2018) mentions that the goals of STEM extend beyond career opportunities and provide opportunities to cultivate critical tools to understand the world to create a more sustainable future. For the UAE, STEM education can help to promote creativity and innovation in all sectors to remain globally competitive (Moonesar et al. 2015). The nation's goals of increasing the knowledge-based economy and expanding Emirati participation in the workforce are connected and have led to the government taking concrete steps to increase the quality of STEM education (Moonesar et al. 2015).

Policymakers and educators around the world are evaluating educational programs more closely to identify the quality of pedagogical practices applied during classroom instruction (Dana & Yendol-Hoppey 2019). Darling-Hammond, Hyler and Gardner (2017) mention that a report on teacher education from a variety of different countries, from the developed and developing world, indicated in their analysis that there is a division between theory and practice. Moon (2016) identified that systems promoting teacher education have improved over time and can be seen to influence their pedagogy. Additionally, it is shown that teachers require support from industries outside of the school community. Darling-Hammond, Hyler and Gardner (2017) highlighted that an increase in teacher education is a common element amongst the five countries, indicating that teaching practices serve as a key initiation point to student achievement.

Lesseig, Slavit and Nelson (2017) claim that STEM education that builds a community for professional development stemming from communication and teamwork serves as a model for others to learn from. Jenset, Klette and Hammerness (2018) specified educational practices across the globe during an evaluation of coursework for the teacher educational programs in Finland, Norway and the United States. One strategy included practicum extension and field placement for teachers (Jenset 2017; Müller et al. 2015). Other best practices include forming links with schools that have new teachers such as the teacher training school in Finland (Canrinus et al. 2019), partnerships with university schools in Norway (Lund & Eriksen 2016) and professional development schools in the United States (Lowery et al. 2018; Maheady, Magiera & Simmons 2016). Professional development in the US included the America COMPETES Act and the America COMPETES Reauthorization Act. Both policies aimed to improve teaching and learning in primary and cycle 2 and cycle 3 schools by focusing on the program and curriculum development of STEM education (Perez & Kumar 2018). These programs help to take education to the next level by forming connections with community-based businesses (Zeichner, Payne & Brayko 2015) and connect teachers with practical teaching methods that are not restricted to school sites (Dana & Yendol-Hoppey 2019). In essence, professional experience that goes beyond the educational institution can build stronger school and community relationships that can help teachers to guide their students and encourage an innovation mindset (Stehle & Peters-Burton 2019). By studying the educational practices of successful STEM countries, the UAE can benefit by learning to develop their own teaching capacity so that educators can effectively teach and promote STEM education.

Technology can also be used by the teacher to support student learning. Yang and Baldwin (2020) reviewed technology-use strategies to create an integrated STEM learning environment by using web-based inquiry, such as WISE and immersive and interactive technology, like virtual gaming and simulation. These tools expand beyond traditional teaching. Regarding programming, robotics and other technologies in STEM, many teachers are concerned that they do not have content mastery in these areas, which is a major obstacle in implementing STEM education. For instance, teachers doubt their competency to lead a programming class as they lack the skills themselves (Bell 2016). The role of the educator, therefore, shifts from knowledge bearer to mentor whose primary function is to ask the appropriately challenging questions and bring about new discoveries (Goodyear & Dudley 2015). From this perspective, the student ceases to be a passive consumer and becomes a producer of knowledge, assuming the protagonist of his or her own education. In addition, there is a complete shift in the way the teacher engages with the student. This new dynamic helps the students to seek answers, solve problems and think systematically (Cinar, Pirasa & Sadoglu 2016). The educator organizes the class in order to stimulate the students to think, propose solutions and collaborate with peers in teams which results in addressing the students' individual needs through rigorous differentiation. The result is more pleasurable work for both those who teach and those who learn. Thibaut et al. (2018) observes that developing digital competencies is embedded in STEM education. This entails utilizing technological tools to access and share information to create knowledge (Sen, Ay & Kiray 2018). Technology integration in STEM education supports the students' learning process by making the class more interactive and requiring problem-solving skills. By integrating technology as a key component in the UAE's STEM education, student-centered learning can promote deeper understanding and engagement through active participation and collaboration.

However, the school environment can also negatively impact students. According to the Council of Europe, studies show that many of the textbooks used in European countries include stories and images that reflect a stereotypical representation of the roles and activities of women and men, girls and boys (Brandy & Keith 2018). This can contribute to an under-representation of women in work sectors such as science or industry. In 2017, the National Science Board in the US notes that there is a drastically lower rate of participation of women since only 28% pursue STEM careers, highlighting the gender disparity (National Science Board 2019). One criticism that arises in opposition to the STEM system is that its main objective is to train small professionals. In fact, this is not the objective of the curriculum at all. The purpose is to give students the opportunity to articulate knowledge, develop skills, think holistically and take on an interconnected perspective of the future from a local and global scale (Winberg et al. 2019). STEM education can improve the UAE by enabling the next generation of innovators.

It is undeniable that the impact of STEM on education is enormous. For instance, the STEM approach has been shown to be effective with students whose focus is diminished by the classroom environment (Barrett et al. 2015; Lewinski 2015). Throughout the STEM learning process, students understand the importance of this method as it enables them to develop 21st century skills essential for the next stages of life (Battelle for Kids 2016). Ehlers (2020) emphasizes that the meaning of knowledge is changing, and that acquiring knowledge is no longer a sufficient end goal. Citizens must be able to use knowledge to create new knowledge. For schools to prepare students for the 21st century, they must develop technological competency, promote collaboration and communication skills, foster curiosity, resiliency, self-organization and vision (Ehlers 2020; González-Salamanca, Agudelo & Salinas 2020).

One of the great difficulties of today's educators and parents is developing the skills needed by their children to prepare them for the future workforce. This is a challenge because traditional learning methods are not so focused on these skills and seem to be somewhat oblivious to the new reality of students in the technological context (Petersen et al. 2018). Yoon et al. (2015) underscore that teachers may even need time to learn the skills first before incorporating them. Technology knowledge is dynamic and constantly changing, and in this sense, STEM teaching stands out as a solution. To become successful in this fast-paced world, students need to enhance their 21st century skills, so technology needs to be employed as a supportive tool to learn with, rather than just a resource to learn from in STEM fields (Petersen et al. 2018; Darling-Hammond 2017; Pasnik & Hupert 2016). In the US, President Obama designated over $400 million to fund STEM affiliated programs. As a response, Hitachi High Technologies America, Inc. (HTA) developed a program that increased nanoscience accessibility for students in elementary schools all the way through graduate schools. HTA collaborated with non-profit partners to provide educational programs focused on nanotechnology (GMIS 2019).

2.2.1.2 Attracting and retaining the best minds

This section includes a discussion of collaborative learning, problem-based learning, and STEM methodologies.

Given that many students struggle with open inquiry, educators should think about using a research-based approach to provide additional academic support. Peer tutoring is one such approach since it has been shown to decrease the learning challenges and increase a student’s interest and self-efficacy in a subject matter. Peer tutoring is defined as individuals, similar in social grouping, supporting each other to learn and, as a result, also learn themselves (Leung 2015). The positive academic effects on the students are well-documented (Tsuei 2017; Zambrano & Gisbert 2015). Some of the documented benefits include an improved self-identity, a more positive attitude towards the subject matter and a stronger dedication to learning (Alegre 2019; Johnson 2019; Zeneli, Tymms, & Bolden, 2016). For example, Zeneli, Tymms and Bolden (2016) discovered that students in eighth grade saw an improvement in their math self-concept, social self-concept and enjoyment of the math subject as a direct result of peer tutoring. Outcomes such as these can be a result of the individualized, friendly, structured, yet relaxed, learning space that one commonly finds in a peer tutoring environment, compared to that of a traditional classroom (Chow 2017). Peer tutoring contributes to the students' improved understanding of the content and, therefore, their academic improvement (Tsuei 2017). To further strengthen this argument, a study on peer tutoring found that student achievement increased in 45 out of 52 reviewed studies as a direct result of this approach (Chng & Lund 2018). Cross-age tutoring, where the tutor is older than the tutee, has also shown the same positive effects as peer tutoring on academic growth and attainment in science in the middle school level (Korner & Hopf 2015).

As shown above, peer tutoring can be very beneficial to students academically, which is another reason why programs such as these need to be introduced to STEM students using an open inquiry method. This is how collaboration will take place and allow learners to support and help each other in multicultural groups, entailing that collaboration must include cognitive and social skills (Sen, Ay & Kiray 2018). Accordingly, communication skills are improved through the collaborative search for solutions. Stehle and Peters-Burton (2019) stress that skilled communication creates the necessary bridge to connect real-world problem solving and knowledge construction. Van Laar (2017) notes that communication skills such as explaining and presenting information can benefit students as they practice reflecting on the ideas and type of media they are using. Also, various work sectors, communication skills are necessary (Joynes, Rossignoli & Amonoo-Kuofi 2019).

Another key component of STEM is the project-based learning (PBL) structure that makes students develop skills to build resiliency, which is a vital 21st century skill. Problem-based learning and project-based learning (PBL) differ in that PBL is a broader area that has various problems and challenges, provides more real-life experience to students and allows students to identify answers in multiple fields. This increases self-efficacy, which in turn builds a lasting set of new knowledge (Fouad 2018; Jamali et al. 2017; Mutakinati, Anwari & Kumano 2018). Fouad (2018) identifies the influence of STEM-PBL on students' learning practices. A great benefit of project-based learning is that it is an engaging instructional approach, which allows students to focus better. Also, STEM-PBL uses collaborative learning, which allows students to learn from their classmates (Samsudin et al. 2020). Because the problems are exciting, the students get involved and maintain concentration until they find a possible solution that is efficient. In this way, they gain a valuable life skill: the ability to focus their attention on a task to do the best they can (Fouad 2018). During the learning process, they can monitor their progress and adjust based on the feedback they are given (Samsudin et al. 2020) Project-based learning is a way of teaching that gives students more room to make mistakes and more opportunities to find a workable solution, helping them to improve these interpersonal skills more easily (Fouad 2018) as they acquire new knowledge (Han 2017).

Methodologies such as STEM-PBL are student-centered: developing greater autonomy and more participation by students so they can learn in a practical way and perfect important characteristics. Trying, making mistakes, getting it right, and building their own solutions. With the STEM methodology, parents can participate and help their children in their school life and prepare them for the future by stimulating the development of cognitive and interpersonal characteristics that are fundamental. The processes are focused on the use of technology, interactive materials and innovative teaching strategies. For instance, the India STEM Foundation, with worldwide partners such as United Technologies, John Deere and Lego, has launched robotics themed challenges to promote STEM education programs through interactive learning. Students aged 9-16 can take part in the FIRST LEGO League (FLL), a robotics competition to find creative ways to solve complex tasks in teams of 2-10, along with the guidance of one adult coach (First Lego League 2020). In 2014, 44 teams coming from 12 states in India gathered more than 300 students to participate in the FIRST India National Championship (First Lego League 2020). These challenging activities are designed to help students advance in their future careers using technology (GMIS 2019). It is important for parents to be aware of these methodologies that are revolutionizing the education sector so that they can seek to improve their children's cognitive and social skills by taking advantage of these opportunities to prepare them for modern life and for the job market (Education Council 2015b). During the last decade, most of the research conducted analyzes project-based learning and reflects the positive impact of STEM-PBL. Research has revealed that STEM project-based learning, when focused on 21st century skills, improves thinking and problem-solving skills (Fouad 2018). Bilgin, Karakuyu and Ay (2015) discovered that students' results were improved when compared to that of traditional teaching methods and gave students a stronger sense of self-capability toward learning science.

2.2.1.3 Future vision

This section includes a discussion of 21st century skills that will enable students to become successful in future labor markets.

During the 21st century, it has been observed that educational systems change to prepare students with the required skills for the future (Education Council 2015). As a result, the educational system must address the barriers that prevent students from attaining the technical education needed to meet the nation's demands for a STEM capable workforce (National Science Board 2019). The required skills for individuals to compete in our current society include primary knowledge, academic skills and literacy skills (Chalkiadaki 2018; Luna Scott 2015). Currently, various skills are needed which implies that the practice of using academic knowledge and applying a skills-based approach has useful applications in the real world. Educational programs have improved to provide various paths for acquiring and improving new skills to meet the changing demands of industries, a feature not found in traditional education (Kivunja 2015; Rahimi, van den Berg & Ween 2015). Since students are competing in the global economy, the curriculum and skills at the K-12 level need to be aligned with this goal (Darling-Hammond 2017). Therefore, the content and curriculum need to be adjusted to remain focused on students' 21st century skills and needs (British Council 2018).

The STEM education practices develop ways for students to recognize and identify objectives to create answers to assigned problems, resolve different issues and explore the approach to improve real life situations (Asunda & Mativo 2016; Drake & Reid 2017; Kasza & Slater 2017). Acquiring these skills will enable them to change and transform the global community since the Global STEM program endeavors to train individuals to become qualified to fulfill the changing needs of 21st century workforce (British Council 2018). It has been identified that STEM education is geared towards developing students' research-questioning, logical reasoning and working behaviors while collaborating with others. Therefore, these skills support students to easily adjust in new situations once they acquire the appropriate knowledge (Petersen et al. 2018). These skills will have to be integrated and delivered by knowledgeable educators, as such, it is vital that teachers collaborate and work together to allow students to benefit from different viewpoints (Posner et al. 2016). The teacher's willingness to teach the program is essential, and they need to be supported to incorporate a STEM program. They need to be provided with quality professional development sessions to gain confidence in teaching methodology as well as having access to the necessary supplies. It is also important to support school facilities so that they can achieve the targets of the program (Petersen et al. 2018).

By developing advanced STEM skills, students are better prepared to cope with future labor market changes. STEM skills. STEM skills develop the Emirati human capital through the incorporation of 21st century skills that increase effectiveness in the innovation process. The integrated nature of STEM learning, which moves away from the traditional teacher-centered approach, embeds the use of technology and collaborative strategies in PBL. PBL provides the opportunity for students to practice decision-making and complex problem solving collaboratively. Collaboration increases independent thinking skills, open-mindedness and creativity through the open inquiry model that facilitates self-directed learning. UAE schools need to continue to produce students who are skilled in STEM and competent in 21st century skills to remain competitive by becoming scientific and technological innovators.

2.2.2 STEM and Careers: Preparing the Future Workforce

There is an increasing lack of motivation in pursuing a STEM career, even though obtaining a bachelor's degree specializing in a STEM field is positively associated with a higher likelihood of employment and higher lifetime earnings (Means et al. 2018). It is necessary to sustain student interest as 40% of students intending to major in math, science, or engineering in college either switch to a non-STEM major before they graduate or don't even graduate at all (Pittinsky & Diamante 2015). Pittinsky and Diamante (2015) propose that a balance between an intrinsic and an extrinsic motivational approach can work to decrease the high STEM dropout rate and increase retention. Values such as grit, curiosity, and mastery can be instilled during the students' K-12 years. It has been studied that persistence in pursuing a STEM career can be increased by a student's academic achievement and STEM preparation in high school (Green & Sanderson 2017). However, the high school education system is not exerting much effort in supporting students to investigate a STEM pathway as a career choice. Green and Sanderson (2017) suggest that policies regarding course selection, such as encouraging or requiring STEM related courses in high school and requiring introductory STEM courses in universities, can effectively increase student interest in STEM careers. Additionally, Petersen et al. (2018) underscore that STEM programs need to motivate students during career fairs by explaining and detailing STEM careers, which can then direct the students towards a STEM path.

The World Economic Forum (2019) observes that the average gender gap measures at 31.4% and needs to be closed on a global scale. However, the average global score is positively increasing due to the gender parity that is being achieved in several countries. This gender gap is also prevalent in STEM education and careers. For instance, the influx of female enrollment at the university level is not reflected in the number of women pursuing STEM careers (Corbett & Hill 2015). Only 29% graduate with STEM degrees whereas 40% of men do (National Student Clearinghouse Research Center 2015). Leslie, Cimpian, Meyer and Freeland (2015) note that disciplines traditionally seen as requiring innate talent, such as physics and economics, have been avoided by women. Gender identities contribute to the STEM gender gap as girls find it challenging to develop a science identity that does not conflict with their gender constructs (Archer et al. 2017). Todd and Zvoch (2019) identify that 11 through 14-year-old girls mark an important stage since the transition from elementary school to middle school results in a decline in interest of students in science, which is disproportionately higher for girls compared to boys. To address this science pipeline issue, Anderhag et al. (2016) highlight the power of classroom experiences to establish science identities. According to Moonesar et al. (2015), intrinsic and extrinsic factors play a role in understanding science identities. The importance of making curriculum relevant and engaging for students is highlighted by Wiebe et al. (2018) noticed the relationship between students' attitudes towards STEM and interest in STEM careers. Also, Aydın, Saka and Guzey (2017) found that students with a high level of positive attitude towards STEM lead towards selecting professions in STEM fields. Ciftci, Topcu and Erdogan (2020) emphasize positive STEM learning to shift student attitudes regarding STEM careers. Moonesar et al. (2015) also recognize competency as taking a part in students' science identity construction. An example of competency-based practices is the incorporation of project-based problem solving through the E-STEM model to include entrepreneurial practices into STEM education (Eltanahy, Forawi & Mansour 2020).

Here we will discuss three important theories that seek to explain the impact of attitudes and values on student motivation, the relationship of "science identity" to retention, and the impact of structural and resource factors on student success. The surrounding environment, the role of the community, and the integration and interaction of different institutions are all playing an integral role in promoting innovation and STEM-centric career paths for students (Petersen et al. 2018; Posner et al. 2016). For instance, various researchers have identified the capacity of the environment to influence the learning experience of students such as the Enriched STEM program. Regardless of the level of the students' mathematical knowledge, participation in the program was adequately used as support for predicting STEM learning goals. As a result, schools should foster long-term interest (Petersen et al. 2018; Worrell et al. 2019). To further expand STEM interest, messages of inclusion are vital since students' choice to pursue STEM careers can be influenced by negative stereotypes or STEM-related discrimination (Falco 2017). For instance, several multinational studies between males and females have shown that there are greater cultural inequalities associated with mathematical accomplishments (Salk, Hyde & Abramson 2017). So that the UAE attracts the best and the brightest minds in STEM fields, the whole population must be considered, and the contributions of women need to be recognized.

Research has shown the impact of gender stereotypes regarding mathematical abilities on STEM identities (Ajai & Imoko 2015; Goldman & Penner 2016; Reilly, Neumann & Andrews 2015; Stewart et al. 2017). It is a complicated task to recognize the age in which gender differences in math ability between male and female students begins. Findings from different research indicate that gender differences include the average for math ability, which in some cases does not become a reliable measure until the mid-age of adolescence (Carli et al. 2016; Wang & Degol 2017). Other findings show that the boys' scores for standardized assessments are not consistent, regardless of the range of the sample, test outcomes, grade level and time of the study (Blau & Kahn 2017). Additional research analyzing the education for girls shows that girls earn higher scores in Math than boys (Hirnstein, Hugdahl & Hausmann 2019). Studies also reveal that while gender disparities in mathematical learning and self-concepts are minute in more egalitarian nations, both boys and girls still maintain a low mathematics self-perception and hold lower interest levels in taking a career path that is mathematics-oriented (Goldman & Penner 2016). To improve STEM education, the UAE policymakers should keep in mind the issue of gender differences and issues regarding low motivation to increase STEM interest.

As young girls mature into adolescence, they lose interest in STEM, so by the time they reach higher education, they only represent 35% of students enrolled in all STEM-related courses of study (UNESCO 2017a). One factor identified by UNESCO (2017a) is the family unit. It is important to note that the cultural values and beliefs about gender abilities are transmitted to children by their guardians. Meta-analysis has identified that parental perspectives reflecting suitable roles for males and females relate to the child's perspective and attitude towards the roles of gender relative to professions in different fields (Meyers-Levy & Loken 2015). Similarly, parents can develop their child's basic skills for improving mathematical knowledge and performance by transferring gender-based beliefs about performance in math. For instance, research has identified that parents transmit gender stereotypes such as boys' performing better in math than girls and math being more useful for boys than girls. Therefore, the parents' expectations for boys are higher, and a lower expectation threshold for ability level is maintained for girls. The parents' beliefs become intertwined with the child's personal ability belief in math (Denner et al. 2018; Muenks, Wigfield & Eccles 2018). Research also highlights that parents' expectations influence girls' career choices whereas boys follow their interests (OECD 2016a). Additionally, children, as early as age four, begin to adjust their behavior based on internalized stereotypes (UNESCO 2017a). This is influenced by parental expectations that reinforce gender roles and negative stereotypes, which can discourage girls from pursuing a career in STEM (UNESCO 2017a). Accordingly, Bian, Leslie and Cimpian (2017) finds that the perceived higher-level intellectual ability in men in math negatively influences women's career interest in that field. As a result, Leslie et al. (2015) stated that women are underrepresented in STEM fields where they are stereotyped as not having the innate ability required for success. In the UAE, girls need to be supported to pursue STEM education and STEM careers, just like boys. However, they need additional support so that they are provided with adequate opportunities to explore STEM and STEM careers.

Milner-Bolotin and Marotto (2018) emphasize how parental engagement benefits the child's achievement in STEM education. One avenue that parents found useful is Science & Math Education Videos for All, which included hands-on STEM experiments and explanations of concepts (Milner-Bolotin 2018a). In Canada, the University of British Columbia hosts the Family Mathematics and Science Day during which parents and children engage in STEM interactive activities (Milner-Bolotin 2018b). Additionally, parent involvement can take the form of challenging common misconceptions with the help of universities and schools that provide information about STEM education opportunities and access to educational advisors (UNESCO 2017a). In the UAE, support for STEM learning opportunities can include initiatives that aim to increase parent engagement to improve the students' STEM learning outcomes.

Future research should aim to identify the educational approaches that recognize the diverse learning styles of both male and female students. In recent decades, improvements in educational achievement that have positively supported both boys and girls in STEM subjects include improving student attitudes about science and math, improving school environments and increasing teacher capacity (Mullis et. al 2016). Professional development that promotes gender-responsive STEM pedagogical practices can help teachers nurture girls' interest in STEM education as they learn about the factors that impact the girls' choice to participate. In 2016, the TeachHer initiative, a global public-private partnership, was launched and it focused on addressing the STEM gender gap. The week-long training workshops were regional and used the network of training institutes owned by UNESCO to create a Master Corps of educators who could teach the STEM subjects using state-of-the-art curricula (UNESCO 2017a). Enhancing teaching practices can also include the use of gender-neutral language, creating experiences that match the diverse interests of students within science and incorporating more inquiry-based lessons that are hands-on and writing intensive (UNESCO 2017a). An example of this initiative is the Ark of Inquiry, which is a joint project that aims to create "new science classrooms" to engage students from 7 to 18 and to empower girls. It is funded by the European Commission with partners from 12 countries in addition to UNESCO (UNESCO 2017a). The UAE can strive to create partnerships between the Triple Helix actors and schools to invest in professional development that encourages gender-sensitive STEM practices so that girls can equally benefit from the program. The focus should be on building all students' STEM skills, regardless of their gender, to increase their interest in STEM careers.

In 2015, the STEM Education Summit, held in Australia, discussed the educational strategy of STEM schools on a national level (Education Council 2015b). A prominent topic of discussion centered on the increasing number of employment opportunities in STEM-related fields, as well as non-traditional STEM occupations that are now requiring technical STEM skills (Education Council 2015b). The need for student career readiness is a priority since it drives economic competitiveness (Vought 2018). The Education Council (2015b) notes that increasing student exposure to information on STEM careers regularly, and starting from an early age, provides encouragement for students to pursue these careers.

Increasing parent knowledge of STEM career options can also influence engagement in STEM, so formal and informal events such as career events should also include parent participation (Education Council 2015). Van Tuijl and van der Molen (2016) highlight that schools play a role in shaping students' STEM career development and should work towards supporting student interests and skills in STEM fields. The Afterschool Alliance (2015) mentions that frequent exposure should also occur in a variety of settings and call attention to the importance of field trips. In the US, the Science Club teams up middle school students and Northwestern scientists in a mentorship program and the Digital Harbor Foundation organizes school day field trips to increase real-world educational opportunities.

Additionally, educational events such as fairs and festivals can further widen students' understanding of STEM careers. The Big Bang UK Young Scientists & Engineers Fair includes workshops, exhibits and career information to inspire students to learn more about STEM career pathways from professionals (The Big Bang 2020). During these academic events, competitions such as The Big Bang Competition help to build confidence while increasing STEM skills by recognizing and rewarding young people's STEM achievements (Big Bang Education CIC 2020). Similarly in the US, the Georgia Science and Engineering Fair (GSEF) recognizes students for their achievements in science and engineering. Participation in the event allows students to present their original research and compete for awards, which encourages students to become influential and productive community members (CCSD 2018). The Science Olympiad provides standards-based science competitions that include lab events and building events (CCSD 2018). Increasing students' self-efficacy in STEM subjects is beneficial because it can also impact their career choice. Sahin et al. (2017) examined 2246 graduates from a STEM-focused public school in Texas and found that the overall percentage selecting a STEM major in college was greater than both state and national averages. Students with higher measures of self-efficacy in math and science were more likely to pursue a STEM field as a college major when compared to students with lower measures of self-efficacy in these subjects. In the effort to increase student engagement in STEM, the UAE can design educational policies that promote extracurricular STEM programs to increase student self-efficacy and develop their interest in STEM career options.

Another method of enhancing student interest in STEM careers is to reference its relevance to personal development. STEM skills and knowledge can be emphasized as being transferable to other career fields (Knight & Bennett 2019). An identity-centered approach to career development promotes a self-awareness that is more mindful and holistic (Watts 2015). Providing support for career development is valuable since many STEM graduates do not persist in STEM fields. Palmer et al. (2018) highlight the significant reduction of STEM graduates in proportion to those working in STEM careers. The leak in the STEM pipeline persists even if STEM degree holders have higher earnings. Nationally in the US, the average yearly salary for STEM workers was $87,570, which is almost double the average yearly salary for non-STEM fields (Fayer, Lacey & Watson 2017). STEM careers provide enhanced salary prospects as well as increased work opportunities. For instance, between May 2009 and May 2015, employment in STEM fields increased by 10.5 percent, resulting in 817,260 jobs. In comparison, non-STEM occupations experienced a 5.2 percent growth (Fayer, Lacey & Watson 2017). In Australia, employment in STEM disciplines accounts for 75% of the fastest-growing professions (Knight & Bennett 2019). STEM careers in the UAE are also experiencing a growth, and Emirati STEM graduates can be given guidance to support their interest in pursuing these high-paying and in-demand careers.

One obstacle in persisting in a STEM career is the flattening in age-earnings. STEM majors experience an initial economic boost in earnings, but within a decade after graduating, they experience a 50 percent decline. To help offset the STEM workers' salary stagnation, Deming and Noray (2018) recommend that policymakers and universities need to balance general skills and technology-specific education to combat the obsolescence of skills. Selingo (2018) notes that "lifelong learning" approaches such as coding bootcamps and stackable credentials can help STEM workers maintain a relevant skill set. More support and resources are needed to ensure that STEM education remains current so that students maintain a competitive advantage.

Out of School Time programs, also known as OST, have also been known to have an inspiring impact on career choices in the science field (Guzey, Moore, Harwell, & Moreno 2016; Guzey et al. 2019). According to a report of An Afterschool Alliance (2015), comparable findings are identified in evaluative data that strongly presents the lasting impact of afterschool programs for students and their ability to connect with STEM. Similarly, Knezek et al. (2015) asserts that middle school and high school students participating in STEM activities increased their interest in pursuing STEM majors. Access to informal learning environments increases STEM interest while supporting STEM skills and knowledge (Denson et al. 2015; Kitchen et al. 2018). Baran et al. (2019) highlights that these out-of-school contexts are not only essential in developing students' STEM attitudes, but also in strengthening the collaboration between schools and universities and providing a way to address underrepresentation and accessibility issues.

When analyzing the relationship between informal STEM learning experiences and future career choices, these STEM-based activities can lead to an increased interest in science by being more hands-on and engaging (Roberts et al. 2018) through real-world problems (Popovic & Lederman 2015). They can help students to develop their ability to recall and understand concepts (Popovic & Lederman 2015). Both student participation in short-term informal STEM programs (Kitchen et al. 2018; King 2017) or long-term informal STEM programs (Baran et al. 2016) have been reported to increase student interest in STEM. Additionally, there is an added benefit of being connected to caring adults that serve as role models, which in turn reduces achievement gaps among the higher income and low-income earning families (NRC 2015). Kupersmidt et al. (2018) pointed out that mentoring has become a strategy to increase American STEM achievement from grades K-12. Programs such as US 2020 and Million Women Mentors have collaborated with STEM companies and employees to join as mentors to students. Baran et al. (2019), after studying a STEM education program designed for sixth graders hosted at a public research university, recommended that policies and research should advocate for designing STEM activities in formal and informal learning environments to consider real-world contexts.

Upon looking at reports examining the impact of participants of OST programs, Roth and Brooks-Gunn (2016) declared that the most important factor in adult-youth relationships is to have an ongoing, understanding connection to STEM. Some have even referred to this connection as the “critical ingredient” (Gupta & Negron 2017). Such reports demonstrate the importance of staff building relationships with youth who are placed in OST programs. Roth and Brooks-Gunn (2016) also noted that many children go to these programs because they are provided support to staff or feel that the adults in these programs’ ‘care’ about them. Habig et al. (2020) examined how the Lang Science Program, a seven-year OST program initiated by the American Museum of Natural History (AMNG), influenced the 6th-12th grade participants’ long-term STEM engagement. The results show that 83.2% of alumni studying a STEM major and 63.1% of STEM alumni pursued a STEM career, with the majority being females and/or from a racial and ethnic group traditionally underrepresented. In the Lang program, the participants highlighted that their persistence in a STEM trajectory was due to the relationships they established with peers and adults, such as the scientists and museum educators. The social networks established extended the duration of the program and the continued contact provided critical support in the form of recommendations, professional networking and college and career advice. Additionally, participation in the Lang program provided students with opportunities to create positive experiences related to STEM. This allowed students to create mindsets that imagined possible selves succeeding in a STEM profession, helping them to persist during tough times.

Baran et al. (2019) also studied the impact of an out-of-school STEM education program, such as a summer camp or a club, influences students' attitudes toward STEM and STEM careers. This influence consists of increasing their motivation to study STEM subjects such as math, science and engineering, while providing guidance towards a STEM career by offering the first step towards a future career choice. Most of the students believe that by having a STEM career, they will have a better quality of life in the future. The research highlights that students make connections about what they learn in theory and their real-world applications, like designing machines, when participating in the informal STEM programs. Petersen, Tillinghast, Mainiero and Dabiri (2018) also encourage competitions in OST programs to increase student growth and student motivation until they graduate. Such positive experiences are necessary as students' resilience in STEM courses at the university level decrease. Due to the increase in rigor of university courses in comparison to those taken in high school, students interpret their lower grades, despite heightened efforts, as a sign of incompatibility in the STEM career path (Cromley, Perez & Kaplan 2015). Additionally, STEM persistence impacts men and women disproportionately. As Green and Sanderson (2017) note in their study that even if female students are 17.5% more likely to graduate from college than men, it is estimated that 15% of female STEM majors are less likely to complete a STEM degree.

Peterson (2017) emphasizes that a student's home life, in addition to their schooling, plays a major role in their learning and development. In a 35-year longitudinal study conducted by the National Academy, Rozek et al. (2017) identified that the parents' ability to nurture STEM interest and convey the societal importance of STEM constituted their impact. Additionally, the link between parents' expectancy and student success needs to be considered as they help to develop motivation and confidence to achieve goals (Ginevra et al 2015). In Ceglie and Setlage's (2016) research based on science learning, they conclude that parents transmit core values such as cultural elements and family norms. Additionally, skills and habits, which include homework completion, are also transferred from parent to child. The combination of values and work ethic expresses the parents' view of science, which compounds over time. Therefore, parents have more influence on their children than teachers. With similar beliefs and goals of teachers, parents have a major impact on their child and their accomplishments (Ceglie & Setlage 2016).

As such, parents are key players in enhancing STEM education. Mihelich et al. (2017) studied attitudes towards science amongst parents and their children in 4th, 7th and 10th grades. Their statistical findings include that parents maintaining a positive orientation towards science are better equipped to support their children's interest and perceived ability in science. Therefore, parental attitudes are important to combat children's declining self-confidence and enthusiasm in science related endeavors. Kahan (2015) supports initiatives that address parents' attitudes to deter anti-science sentiments such as incorporating more parent involvement in schools. Rozek et al. (2017) found that high school STEM preparation and career pursuits were significantly affected by a parent intervention consisting of parents encouraging their children to enroll in high school STEM courses. Peterson (2017) recommends both formal and informal outlets for parents to become involved in STEM education such as Career Night and Family STEM Night. Parents need guidance so that their influence can become more targeted. Simpkins, Price and Garcia (2015) found that positive experiences for students deriving from parent-school oriented behavior contributed to their science achievements. Similarly, students benefit from the active role of parents because they become better learners, regardless of race, income or the parents' education (STEMx 2020). Parents serve as main stakeholders by providing both educational and career guidance (Hlado & Jezek 2018). In the Interest and Recruitment in Science (IRIS), an international study funded by the European Union, a major finding is the proven effects of parents on adolescents selecting STEM disciplines and pursuing STEM careers. Guan et al. (2016) proposes that parental support creates a context that influences a child's self-efficacy related to career decision-making by building autonomy and independence. Additionally, Garcia et al. (2015) determine that the parent adolescent relationship, supportive parental behavior and perceived parental support function as predictors and sources of career decision-making self-efficacy. Parents also provide guidance by being positively associated with the career self-exploration of adolescents (Kanten et al. 2016).

Velez-Agosto (2017) evaluates that cultural expectations serve as important factors in child development. Since parent expectations are shaped by cultural contexts, they can influence their child's achievement level in STEM-related subjects. This can be observed in how children's self-efficacy and academic achievement across all ages are aided by parental expectations (Thomas & Strunk 2017). In terms of careers, Ertl et al. (2017) recognize that an alarmingly low proportion of females are pursuing a career in STEM. This underrepresentation relates back to parental expectations since Schuster and Martiny (2017) indicate that one of the reasons females avoid STEM subject's links to the negative and stereotyped views of these subjects. Lee et al. (2019) recognize that parents transfer values through socialization differently depending on their child's gender, creating the possibility of tracing the under-representation of women in STEM-related careers to its root cause. Thomas (2017) describes that the STEM is male-dominated stereotype, which is implicitly conveyed by teachers or peers, stigmatizes adolescent girls to follow it both implicitly and explicitly. Sansone (2019) recognizes that the percentage of female students believing that men were better than women in mathematics in ninth grade were 15% but jumped to 25% in 11th grade. Lee et al. (2019) recommends expanding the multiple social agents that adolescent girls use for support, both inside and outside of the classroom, in order to support their internalization of STEM motivation and values. According to Chen et. al (2019), role models play a key role in helping female students to establish science identities by increasing their awareness of the presence and achievements of female professionals in each STEM field.

The Economist Corporate Network (2016) recognizes that the growing disparity between the skills and abilities of young people and those that employers are seeking will impact economic growth. Many countries such as the US, Spain, South Africa and China are confronted with a skills deficit that are connected to specific jobs that are growing in demand. Clark (2017) also mentions that the skills gap can be seen globally, however, countries are developing and implementing educational systems that are focused to meet their needs for an educated and skilled labor force. Due to an increasingly complex world, STEM efficacy needs to be a priority in a student's learning development (Peterson 2017). STEMx (2020) also recommends the importance of prioritizing STEM skills due to the greater income and higher quality of life they can lead to.

In March 2017, the Crown Prince of Abu Dhabi and Deputy Supreme Commander of the UAE Armed Forces, His Highness Sheikh Mohammed bin Zayed, told a group of UAE youth that the future of the UAE "will not come through oil" and will rely on their skills. At the same forum, the Minister of Foreign Affairs and International Cooperation, His Highness Sheikh Abdullah bin Zayed, told the youth that "You are no longer competing amongst yourselves, but with the greatest minds around the world" and acknowledged that the time of prosperous government jobs was coming to an end (British Council 2018). The messaging from both leaders encouraged Emirati youth to pursue science, technology and mathematics. STEM graduates will require skills, experience and knowledge that will allow them to navigate the changing demands of the labour market (Knight & Bennett 2019). In their study of the STEM job life cycle from 2007-2017, Deming and Noray (2018) distinguished between a shortage of STEM workers and STEM skills. The shortage in skills is due to the technological progress that is rapidly changing the requirements of STEM jobs, which makes job tasks that were learned previously to become obsolete. In April 2018, the UAE government launched the National Science Agenda 2031 to develop the scientific community (Mohammed Bin Rashid School of Government 2019). This initiative helps to support students with the STEM education foundation and STEM skills they need for the future global economy that has an increasing demand for STEM careers (British Council 2018).

2.2.3 Triple Helix Model to Implement STEM Education

According to Halibas et al. (2017), the Triple Helix model of innovation was developed by Etzkowitz and Leydesdorff and it has been used to study innovation systems and their production of research projects on a national level. By using the Triple Helix model, countries can enhance and accelerate their knowledge-based economies through the interactions among innovation actors (government, university and industry). Each Triple Helix actor adds to their traditional responsibilities by adopting the role of the other, such as universities extending their responsibilities beyond producing trained graduates and the industry working to use the knowledge created to commercialize it (Chryssou 2020; Etzkowitz & Zhou 2018). The entrepreneurial university is the result of the collaboration between the educational institution and external partners (Fernández-Nogueira et al.

2018). These Triple Helix partnerships not only foster a connection with the business world, but they also enable knowledge to be shared for students in an experiential way that focuses on a solution-based approach for real-world problems (Fernández-Nogueira et al. 2018).

According to Andree and Hansson (2020), a strong foundation for STEM in early schooling can support students to pursue an interest in STEM as they mature. The quality of learning relies on the individuals involved and their willingness to change their methods. Additionally, leaders play a key role since they can communicate the STEM vision and strategies. Their efforts can empower the educational institutions to holistically support student needs (Iskander et al. 2016) and drive STEM education initiatives to sustain and grow pedagogical improvements (Knaub, Henderson & Fisher 2018). According to the OECD (2018), empowering students by providing STEM learning opportunities in their early years increases individual, socio-economic and environmental well-being. Regarding social skills, the International Labour Organization has developed key competencies that are needed to become employable. Leaders can support these interpersonal skills by creating a framework for students to learn skills mastery. For example, the Skills Builder Partnership creates a linkage between schools, families and industry to build teamwork and leadership skills that align to specific activities (World Economic Forum 2020). Regarding STEM content mastery, leaders also play a key role since school culture and learning are linked (Lochmiller & Acker-Hocevar 2016). Therefore, the quality of STEM education is a reflection of the school leaders. This shows that school leaders need to stay current on STEM education reforms, provide support for reforms (Waight, Chisolm & Jacobson 2018). Similarly, Lochmiller and Acker-Hocevar (2016) suggest that school leaders can influence math and science achievement by encouraging conditions that promote teacher collaboration and instruction with innovative practices. Lochmiller and Acker-Hocevar (2016) recommend that for math and science, school leaders can advocate for instructional approaches that are process-oriented and inquiry-based, prioritize formative assessments, and invest in professional development. School leaders can also continue to provide instructional support by attending content-focused professional development so that they can increase their knowledge in subjects that they may not be familiar with and effectively coach teachers (Steele et al. 2015). It is important to note the impact of the instructional leadership of principals because it is shown to have a positive relationship on student achievement (Hitt & Tucker 2015). In summary, school leaders play an important role in sustaining STEM reforms and ensure its success by acting as instructional leaders, providing a clear STEM vision for the school, and maintaining high expectations for all stakeholders (Rangel 2017).

The integration of STEM subjects is aligned with the development of the workforce to promote economic growth (Sen, Ay & Kiray 2018). Therefore, schools are looking to develop career education to prepare students for their future careers. Falco (2017) points out that professional school counselors are important in supporting positive career outcomes because they can provide responsive services and effective interventions that maximize STEM career development opportunities. Studer (2015) highlights that school counselors serve as a vital source of career information in the K-12 settings. Different countries have varying approaches to career education, meaning different roles for school counselors (Ithaca Group 2019). In the US, the Comprehensive School Guidance Program (CSGP), which is endorsed by the American School Counselor Association, is implemented by careers counsellors who are given time and resources to manage the program and deliver information that require professional expertise (Ithaca Group 2019). In Switzerland, the Canton of Bern has carried out mandatory career counselling and career education lessons for all seventh and ninth grade students. Students learn about different occupations, academic and vocational training pathways. The program also includes visits to companies and to prepare for interviews, which can then turn into internships (Ithaca Group 2019). In Denmark, Youth Guidance Centres work with grades 1-10 and provide support through mentorship programs and work placements. Grade 9 students collaborate with centre staff to create individual plans that describe their learning and career goals after completing middle school (Ithaca Group 2019). School leaders, along with school counselors, also play a role in supporting students to pursue a STEM career. They can promote student STEM career education with time allocation, adequate resourcing and public support. Bystydzienski et al. (2015) stated that STEM career interest can be increased when students have rewarding experiences in school while exploring math and science. School leaders can facilitate these experiences by engaging industrial actors in STEM education. For example, in Sweden, a partnership between local schools and a metals company is established as the latter provides courses for students (Andree & Hansson 2020). Also, Indonesia's Accelerated Work Achievement and Readiness for Employment (AWARE) project aims to create a future-ready workforce by providing job-readiness training and workplace opportunities to students age 16 or older in Indonesia and the Philippines (World Economic Forum 2020). AWARE connects students, schools and industry leaders through the structured, work-based learning program that includes collaborating with over 65 private sector companies (World Economic Forum 2020). By collaborating with industrial actors on STEM initiatives, school leaders create the space for industrial actors to influence the attitudes, knowledge and choices of young students (Andree & Hansson 2020). Barber et al. (2020), through their study of using action research to enhance STEM programs, reiterate the need for collaboration and the involvement of all stakeholders to increase student commitment to STEM.

Interest in STEM education and careers can also be bolstered through the involvement of STEM expert adults (Gamse, Martinez & Bozzie 2017). Expert adult involvement in STEM education can include professionals, university faculty and students within the community. Also, the programmes that are created can have various goals and roles for participation (Gamse, Martinez & Bozzie 2017). Shin, Levy and London (2016) find that students benefit from role model biographies that challenge negative stereotypes such as only certain members, like men, can thrive in STEM and that STEM requires innate intelligence and talents. For girls, not having a female role model can contribute to the idea that STEM is not suitable for them (Zachman 2018). These stereotypes are important to investigate because they can contribute to the low levels of recruitment and retainment in STEM education (Leslie et al. 2015). By increasing students' STEM interest, the growing demand for STEM professionals can be met (Shin, Levy & London 2016). STEM expert adults can serve as mentors and can become involved in numerous ways such as serving as coaches, informal or formal educators, or stand as a role model for working in a specific STEM content area (Gamse, Martinez & Bozzie 2017). Petersen et. al (2018) found that experts facilitating field trips such as visits to production facilities and working laboratories give students lifelong memories that can be considered as a "life changing experience" (LCE), which is stated in feedback from participating students, teachers, and parents. In Europe, the European Roundtable of Industrialists (ERT), a group of leaders from major companies, have made it their mission to use STEM education to secure social and economic success (Andree & Hansson 2020). Europe's drive to remain globally competitive can be seen on a national and regional level. In Sweden, technical charter schools work with companies, such as the pharmaceutical industry, to create a skilled workforce that supports the infrastructure to power national prosperity. In collaboration with the government, policies have been designed to broaden the role of experts in STEM education. In 2013, the US2020 initiative focused on matching low-income children, female students and minority students with STEM mentors in order to prepare them for STEM-related careers (Gamse, Martinez & Bozzie 2017). STEM experts can work to build a relationship between economic growth and education by investing their time and efforts in STEM education (Andree & Hansson 2020).

2.2.3.1 Coordination and Communication among Universities, Industries and STEM Government

The government plays a key role in advancing STEM education. In the US, the Federal Government is working in close partnership with stakeholders to increase participation in STEM careers. These strategic partnerships bring together universities, schools and community resources to create enriching learning experiences to develop high-quality student skills. For instance, STEM programs can collaborate with university to create gaming workshops that exercise creativity (Vought 2018). According to Serdyukov (2017), education must evolve to keep pace with the fast-changing globalized world. Education can increase its level of relevancy for students by embedding real-world contexts into school curriculum (Chong, Shahrill & Li 2019). One example can be seen in Alaska as a dialogue between STEM education and the changing environment is extensive in terms of creating solutions. There is a drive to increase both the research and adaptive capacities of its communities for innovation. The University of Alaska (UA) was funded by the State of Alaska and the National Science Foundation Experimental Program to Stimulate Competitive Research (NSF EPSCR). Through this collaboration, the "Alaska Adapting to Changing Environments (Alaska ACE)" program was launched, and it included the Education, Outreach and Diversity (EOD) Group (Sparrow et al. 2017). These innovative STEM education strategies aim to attract and support students' interest in STEM by using real-world problems. One outreach activity is the Global Learning to Benefit the Environment (GLOBE) program during which student participants learn about earth systems and scientific protocols over the course of 6-days through presentations by scientists, indoor and outdoor activities and field trips. Educator participants guide students to conduct their own local research investigations so that they can contribute their findings to one of GLOBE's data archives (Sparrow et al. 2017). With the help of the government, students' STEM learning experiences can be expanded.

Additionally, broadening the educational community to include community resources can foster work-based learning through internships (Vought 2018). Internships are beneficial because they can support STEM engagement by expanding the number and types of adults that students interact with (Gamse, Martinez & Bozzie 2017). Industry partnerships, which involve new community members, can also help by enabling educational leaders to enhance STEM programs through their role in facilitating informal and formal work-based learning strategies through internships (Vought 2018). NASA provides internships so that students and educators can work with career professionals. NASA also provides fellowships, which are merit-based learning programs that develop knowledge in a specific field, that allow students to contribute to advance NASA's goals while gaining valuable learning experiences (NASA 2020). These work-based strategies have a positive impact on the community and/or society since it increases student employability by developing their level of competency and preparedness (Fernández-Nogueira et al. 2018), while addressing the need to raise STEM occupational literacy (Ali & Muhammad 2018; Watts 2015).

Governments play a role in supporting STEM education in the educational system by removing barriers to participation in STEM careers. With government involvement, students have more opportunities that immerse them in STEM learning experiences that welcome trial and error while building strong relationships with peers and mentors (Afterschool Alliance 2015). As mentors, STEM education leaders have aimed to expand

STEM learning to include critical thinking skills and behavioral attributes such as cooperation, perseverance and adaptability since these 21st century skills help students to be successful in the learning environment (Battelle for Kids 2019). These non-cognitive 21st century skills will also prepare students for the future workforce that is rapidly being advanced by technology and globalization, since employers need flexible workers who are lifelong learners (Schnittka 2017). Governments facilitate students' STEM career paths by supporting this comprehensive educational approach. For instance, the US Federal Government invests by funding projects to promote transdisciplinary STEM learning opportunities like science fairs and robotics clubs to help to increase STEM literacy and the behavioral competencies of 21st century skills (Vought 2018). With more funding, schools can create the technical infrastructure to support STEM learning (Koc & Demirbilek 2018).

Also, grant-making agencies on a federal level can support capacity building and equip educators to build the skills and knowledge necessary to support STEM education (Vought 2018). A second example of the government supporting STEM careers is represented in the Program for Educational Cooperation, which is an international collaboration between the Federal Education Institute (IFE), a multinational shipyard subsidiary headquartered in Singapore and the Brazilian state government. First, IFE's role was to recruit students and professors who were highly qualified to take part in the Educational Cooperation Program. Second, IFE would promote the knowledge acquired in Singapore by creating university courses and a doctoral course with an emphasis in naval technology. The university and industry collaboration is only made possible by the state government acting as an intermediary and a regulator (Doin & Rosa 2019). As a Triple Helix actor, governments work towards fixing the STEM pipeline by endorsing mentorship programs, emphasizing 21st century skills, providing professional development for educators and influencing public policies to focus on innovation. According to Vought (2018), the Federal Government plays an important role in encouraging STEM education by collaborating with stakeholders to remove the obstacles to participation to increase access to STEM careers.

Universities also have a critical role in achieving economic growth in today's knowledge-based societies (Pinheiro et al. 2015a) by providing sites for innovation and by creating a support structure that allows teachers and students to develop new projects that are intellectual, commercial and both (Ankrah & Omar 2015; Fernandez-Nogueira et al. 2018). Fernandez-Nogueira et al. (2018) highlight that universities are adapting to societal changes by taking part in the entrepreneurial society and process by partnering with associations, institutions and companies. By collaborating with industries, universities acquire funding, and in many countries, a significant source of funds for research and development come from business projects and international organizations (OECD 2016b). Accordingly, collaborations between universities and industries have been established worldwide (Awasthy et al. 2020).

University partnerships can also encompass professional development. For instance, the STEMITL project involved an interdisciplinary collaboration between a Southeastern University's middle grades education department and the local Professional Development School (PDS) partner school districts. The project designed six full-day immersive projects for seventh graders. Positive feedback from the program included the teachers' ability to plan and deliver content in all subject areas as well as making the link between universities and the school system apparent (Suriel at el. 2018). Professional development is essential because integrating STEM curriculum, instruction, and assessment requires new methods of teaching, learning and instruction grounded in the cognitive sciences (Thibaut et al. 2018). For instance, collaboration between teachers and university faculty was beneficial for the participants in the 2018 STEM Summer Camp since both partners were able to engage and provide feedback on experimental instructional approaches (Guffey et al. 2020). Additionally, the Teachers Exploring STEM Integration (TESI) project aimed to increase STEM literacy during a two-week summer program for both teachers and students through the completion of STEM Design Challenges (DCs). These challenges could not be solved using only one disciplinary approach and required teachers from different content areas to collaborate during the school year to plan for and implement the DCs. Teachers benefited from professional development as the TESI project increased their understanding of STEM integration by utilizing several resources to increase problem-based learning and student-centered instruction (Lesseig, Slavit & Nelson 2017).

Regional innovation is becoming more dependent upon university-industry collaboration to promote innovation. This is seen in the policy trends that promote innovation systems through knowledge transfer between industry and science (Morisson & Pattinson 2020). Fonseca and Salomaa (2020) expands upon the new purposes of universities through their interactions and collaborations that aim for innovation. Universities now impact regional development through licensing, collaborative research, technology transfer offices and consulting services. Universities have extended their mission beyond education and research to behaving more entrepreneurially. The new roles of universities impact the economy because economic growth can also be powered by the additional investment in research and development (Appelt et al. 2016). Additionally, with the help of policies, business firms are now supported to develop new knowledge that benefits society by improving markets and industries (Appelt et al. 2016). As nations aim for innovation, the importance of the Triple Helix model is stressed as the diverse interactions between the key players makes knowledge transfer possible (Morisson & Pattinson 2020).

Commercializing knowledge requires universities and private companies to interact frequently and iteratively along with effective policy solutions (Morisson & Pattinson 2020). Chryssou (2020) study concludes that barriers to university-industry collaboration encompass organizational culture and communication constraints. To sustain a successful innovative ecosystem, Chryssou (2020) recommends that higher educational institutions should be adequately funded with incentivized academic staff participating in research with appropriate facilities, industry players able to absorb and use the results of joint initiatives, incentives for both members to communicate and collaborate effectively, and policies with frameworks and structures that outline the scope of the partnerships. To further accelerate and encourage university-industry collaborations, Awasthy et al. (2020) propose suggestions to facilitate successful initiation and implementation. Measures for universities to adopt include: creating a collaborative platform so that people can reach out to network and discuss ideas and achievements, employing people with an entrepreneurial mindset so that they are both academically capable to understand the research and communicate its significance to marketing people, refocusing researchers to think about the real-world application of their research instead of the research outcome just as a publication and more active participation to commercialize research results. Recommendations for improving university-industry collaboration include: creating a rewards system to acknowledge the efforts of academics collaborating with industry, adopting policy interventions that support the research environment, involving suitable people who positively impact relationships by crossing boundaries such as managers capable of effective project management and leaders with entrepreneurial behaviour, developing an understanding of the variety of relationships so that the selection of a partner matches the context, creating an understanding of intellectual property concerns, improving communication between stakeholders and strengthening strategies for dissemination and use elements of marketing to share results and to attract new partners.

Successful relationships between universities and industry can be seen in different parts of the world. These university-industry linkages encourage economic growth and socio-economic advancement in an economy, and the government can be the coordinator of the linkage between universities and business/industry. This coordination can be facilitated by passing legislation that ensures interaction as well as protecting the rights of each party. It has been found that the government may have both supportive and evaluative roles in the Triple Helix model. For instance, the government can set up fiscal incentives to develop links among institutions, businesses and governments in the form of grants and advantageous tax treatment to promote joint ventures (Appelt et al. 2016). In Germany, the Inventors' Law was passed in 2002 under which university scientists give their university notice of an invention and they are entitled to receive 30% of revenues generated through the usage of the invention. The law aims to compensate the university scientists' loss of exclusive intellectual property (IP) rights to their inventions (DST Ministry of Science & Technology 2020). Germany is leading in innovation as the industry funds about two-thirds of all research and development (R&D). In Japan, the Bayh-Dole Act was enacted in 1999 and changed the rule of ownership for inventions created by research institutions and universities. Universities and research institutions are now permitted to retain intellectual property rights from government contracted research and developments (DST Ministry of Science & Technology 2020). The research linkages between Japanese universities and industries are growing and the government supports scientific development to boost economic growth (DST Ministry of Science & Technology 2020). Chinese universities collaborate with industries in three ways: collaborative R&D between universities and industries, technology transfer between universities and industries and university run high-tech companies. The public sector plays an equally active role as governmental agencies define R&D objectives and government labs are used to conduct R&D. As a result, governmental policy also drives the university-industry linkages (DST Ministry of Science & Technology 2020). To support the national economy and to stay globally competitive, countries have their own variation of linkages between the Triple Helix actors to meet their specific needs (DST Ministry of Science & Technology 2020). For organizations to be creative and productive, there must be harmony between its components (DST Ministry of Science & Technology 2020). Governments can help to ensure that they build the infrastructure to boost their economies and tap into the benefits of technological changes through the Triple Helix model. Countries can further develop local capacity for innovation by utilizing Triple Helix actors to collaborate on science and technology educational policies (Kucircova 2019). Students must be provided with learning experiences that inculcate free and independent thinking throughout their educational path to reach their STEM career paths. They need to be trained to solve problems, deal with inquiry and discover new ways of thinking (Kucircova 2019).

2.3 Summary of the Literature

The literature review explored the importance of STEM Education and the importance of the STEM careers for the UAE’s future and reflected on how the Triple Helix model can contribute to improving STEM education and developing STEM careers. The communication and collaboration between the Triple Helix clusters benefit the UAE because it can produce a knowledge-based society that is in line with their vision.

Due to the UAE's focus towards globalization and orientation towards a knowledge-based economy (British Council 2018), the nation has long recognized the importance of STEM technology and innovation in determining the sustainable future of the nation (Mohammed Bin Rashid School of Government 2015). As such, the connection between innovation and human capital highlights how the workforce is the country's greatest resource, and the workforce must be matured (Mohammed Bin Rashid School of Government 2015). For policymakers, the growing UAE job market provides a great opportunity to assist Emirati youths to secure jobs that are both well-paying and of good quality (British Council 2018). As a result, global educational standards have resulted in redirecting UAE leaders to consider their educational approach to align the performance of Emirati students with the development of global performance standards related to STEM (Benjamin 1999, cited in Zahran et al. 2016). The focus on STEM education and careers has been increased to attain the goal of building individual student ability by developing 21st century skills to enhance entrepreneurship and employment opportunities to sustain global competitiveness and economic growth (Mohammed Bin Rashid School of Government 2015). In the UAE, the 2031 Agenda aims to utilize advance sciences in the development and creation of solutions for the challenges of the future such as National capacity-building, promoting the sustainable energy sector, enhancing water security, using advanced and clean technology, developing advanced scientific food security system and addressing health challenges in the UAE through a national scientific system (Mohammed Bin Rashid School of Government 2019).

Ehlers (2020) notes that learning must adapt so that it can address the constant changing demands required by the labour market while building the capabilities of individual students to cope in these conditions. The National Science Board (2019) highlighted that STEM education is necessary to support future economies. Accordingly, countries are developing educational systems to meet the needs for an educated and skilled labor force (Clark 2017). To meet future needs, STEM incorporates 21st century skills to support students' success in the workforce (Al Sawaleh et al. 2017; British Council 2018; Colucci-Gray et. al 2019; Colter 2018; Kasza & Slater 2017; Mutakinati et al. 2018). For instance, the necessary problem-solving and analytical skills can be found in STEM education (Purzer & Shelley 2018). STEM students explore different approaches to improve real life situations (Asunda & Mativo 2016; Drake & Reid 2017; Kasza & Slater 2017), which emphasizes self-learning (Samsudin et al. 2020); Kasza & Slater 2017). As a result, critical thinking skills are developed through STEM's problem-based approach that encourages multidisciplinary thinking (Colter 2018; Shattock 2009). The STEM education program, which combines technology and design, can support students to create original and innovative solutions to problems affecting human life and the environment (Sen, Ay & Kiray 2018).). This is due to the integrative feature of engineering, which is a key feature that benefits the other components of STEM education (Purzer & Shelley 2018). Additionally, STEM fosters digital competencies (Cinar, Pirasa & Sadoglu 2016; GMIS 2019; Pasnik & Hupert 2016; Sen, Ay & Kiray 2018; Thibaut et al. 2018; Yang & Baldwin 2020). Furthermore, the EARTH design can support the STEM education system by bringing together the stakeholders in the school and the Triple Helix clusters to support real-world innovation, thereby improving the STEM curriculum (D'Este & Perkmann 2011; Mandrup & Jensen 2017).

To attract and keep students in STEM, the education programs need to address issues of support in terms of curriculum, professional development and resources. Firstly, the quality of the STEM curriculum is important because making it relevant and engaging has been linked to student motivation (Roberts et al. 2018; Wiebe et al. 2018). Improvements to curriculum can also include creating STEM-based activities related to real-world problems, making it more hands-on and engaging which can lead to an increased interest in science (Popovic & Lederman 2015). Motivation in STEM can also be increased by learning supports. STEM education supports student learning through scaffolding and collaboration and mentoring is used as a strategy to increase STEM achievement (Achzab, Budiyanto & Budianto 2018; Admawati, Jumadi & Nursyahidah 2018; Kupersmidt et al. 2018; Williams 2017). The deliberate design of STEM learning experiences yields benefits as Habig et al. (2020) observed that OST programs can influence long-term STEM engagement. Secondly, research has found that countries are investing in professional development for STEM teachers (Canrinus et al. 2019; Jenset 2017; Lund & Eriksen 2016; Müller et al. 2015). Research has shown that there are gaps in teacher education that create a division in theory and practice (Darling-Hammond, Hyler & Gardner 2017). Thirdly, it has been found that teachers need more access to necessary supplies for STEM (Moon 2016; Petersen et al. 2018).

Although educational programs play a key role in influencing student career choice, there are additional factors to consider. According to social Constructivism, social interactions drive learning and development. The environmental factors that the student socially engages with can impact their career choice and include student perceptions, cultural aspects and family. The family influences students’ career choices because the unit transmits cultural values and beliefs about gender which impacts STEM career choices (UNESCO 2017a). Also, parent engagement influences student STEM achievement (First Lego League 2020; Milner-Bolotin & Marotto 2018). Parents can also disproportionately influence student career choice as research highlights that parents’ expectations influence girls' career choices whereas boys follow their interests (The World Economic Forum 2019). Additionally, the Social Cognitive Career Theory (SCCT) provides a model for students' career choice by measuring self-efficacy, outcome expectations and personal backgrounds (Hackett 2002; Lent, Brown & Hackett 2002; Leong 2008; Schultz & Schultz 2016; van Tuijl & van der Molen 2015). Both theories take into consideration the contextual elements that can support and/or hinder student learning. To help direct students towards a STEM career, the Triple Helix actors can increase their promotion of STEM education within the students' social context (Elsholkamy 2018). Government, university and industry can collaborate to create internships, after school programs and guidance to increase student exposure to STEM careers. Collaboration between stakeholders is needed to increase student commitment to STEM (Andree & Hansson 2020; Barber et al. 2020).

Developed by Etzkowitz and Leydesdorff (1995), The Triple Helix model of innovation has been used to study innovation systems on a national level. Through the interactions among innovation actors (government, university and industry), countries are able to enhance and accelerate their knowledge-based economies. (Cai & Liu 2020; Etzkowitz & Zhou 2018; Halibas et al. 2017). Through collaboration, the Triple Helix actors are able to organize initiatives that rely on mutual dependency (Etzkowitz 2014; Etzkowitz & Dzisah 2013). By adopting the role of the other actor, each Triple Helix actor adds to their conventional responsibilities (Etzkowitz & Leydesdorff 2000; Etzkowitz & Zhou 2018). According to Institutional Theory, the innovation system fostered by the dynamic interaction between the Triple Helix actors promotes economic growth (Schiller & Leišytė 2020). Chryssou (2020) highlights that there should be incentives for Triple Helix members. The increased interaction between the Triple Helix actors supports institutional development as the institutions adapt and take on characteristics of their partners through the knowledge-transfer framework. As institutions become hybridized, continuous communication between the Triple Helix actors can work towards improvement and achieving strategic economic goals (Etzkowitz & Zhou 2018). STEM education programs can benefit from the Triple Helix components since it creates opportunities for institutions, such as the government and industry, to extend their support. Improving the STEM program is crucial to preparing students for the future STEM workforce, which is critical for the innovative capacity of a nation.

The collaboration between the Triple Helix actors can benefit STEM education programs in different ways. For example, STEM learning experiences are expanded to include real-world problems with the help of funding and resources from the government (Sparrow et al. 2017). Governmental schools can also create partnerships with universities, which currently play a role in achieving economic growth in today's knowledge-based societies (Pinheiro et al. 2015a). The collaboration between governmental schools and universities can create informal STEM programs that help to address underrepresentation and accessibility issues for students (Baran et al. 2019). Universities can even provide sites for innovation by creating a support structure that allows governmental teachers and students to develop new projects (Al-Tabbaa & Ankrah 2016; Fernandez-Nogueira et al. 2018). In order to support STEM teachers, universities can guide professional development in order to successfully integrate the STEM curriculum (Thibaut et al. 2018). University and industry partnerships can also benefit STEM education programs. These university and industry partnerships can result in internships that provide informal and formal work-based learning experiences which can increase STEM engagement (Committee on STEM Education of the National Science & Technology Council 2018; Gamse, Martinez & Bozzie 2017). For instance, they can create job-readiness training. In Sweden, students are taking classes from a metals company (Andree & Hansson 2020). In Indonesia, the Accelerated Work Achievement and Readiness for Employment (AWARE) project recruits students aged 16 or older in Indonesia and the Philippines to join-readiness training and workplace training opportunities (World Economic Forum 2020). University and industry linkages have been shown to increase economic growth (Appelt et al. 2016; Scharmer & Käufer 2000). In Japan and China, their industries are growing through scientific research and development partnerships (Chong, Shahrill & Li 2019; DST Ministry of Science & Technology 2020).

CHAPTER 3: Methodology

This chapter will begin with the presentation of the research design, site, population, sampling and participants, instrumentation, reliability and validity, data analysis and ethical consideration. An exploratory sequential mixed method approach was implemented in this study. The purpose of the research was to investigate the common themes related to the formal and informal STEM education, along with the stakeholders' perceptions and responses on formal and informal STEM education programs, STEM careers and the Triple Helix model in the UAE.

3.1 Research Approach

The mixed method approach is gaining rapid fame in the field of education research since it offers a better understanding of the research problem by using multiple approaches that complement each other (Onwuegbuzie & Leech 2004; Driscoll et al. 2007, Johnson, Onwuegbuzie, Turner 2007). Within a mixed-methods study, the researcher must take into consideration the overall design of the study, the level of interaction between qualitative and quantitative components, the priority of each type of data will be collected and analyzed and the pacing of the study (Creswell & Clark 2011). In behavioral and social sciences, the mixed method approach began to be used as a category for conducting research in the 1980s (Teddli & Tashkuri 2009). According to Cohen, Manion and Morrison (2013), quantitative research is sufficient for generalizations, however, we need to add qualitative research when we need in-depth information.

According to Cresswell (2013), the mixed method design is generally used when both quantitative and qualitative data are needed to answer the research questions or understand the research problem instead of just using each method by itself. The quantitative approach is mainly a deductive method that is ideal for measuring known phenomena including assumptions and inferences of causality, while qualitative, which is an inductive method, is used to identify a previously unknown process or explain why and how phenomena occur (Pasick et al. 2009). The combination of using quantitative and qualitative data begins with the assumption that researchers gather evidence based on the nature of the questions and theoretical frameworks (Pasick et al. 2009). Using a mixed research design is advantageous because it benefits from the strengths of qualitative and quantitative methods while decreasing the weaknesses that might occur in each method (Brewer & Hunter 1989; Johnson & Turner 2003). Mixed methods research is useful when one type of data is insufficient to address the research problem. Quantitative and qualitative data function to strengthen each other when explanation or elaboration is necessary. In this study, the underlying reason for implementing the quantitative approach is to utilize the numeric data. Additionally, Fraenkel, Wallen and Hyun (2015) highlight that the use of qualitative data expands the sources of information to develop a deeper understanding of the phenomena, which is why this research study also includes the qualitative component. Accordingly, this study implemented an exploratory sequential mixed method approach, beginning with document analysis (see Appendix 1), followed by the questionnaire and lastly, the semi-structured interviews were conducted.

This study followed Creswell and Clark's (2011) description of an exploratory sequential mixed methods approach. The exploratory sequential mixed method approach begins with a qualitative exploration (Creswell et al. 2007; Creswell 2009). This design is useful when a framework or theory is lacking (Creswell & Clark et al. 2007) and can be used to transfer qualitative findings to different populations (Creswell 2009). As mentioned earlier in this chapter, other industrial countries have included the Triple Helix model in their STEM education policy with great success. Therefore, it is important to research the applicability of the Triple Helix model in the UAE because it can help to achieve the UAE

Vision 2030 by benefiting formal and informal STEM education programs and future STEM careers. Fraenkel and Wallen (2009) highlight that data collection and analysis in a mixed-method design can happen sequentially so that one research question is answered before continuing on to the next research question. Creswell et al. (2007) also mention that a quantitative instrument can be implemented based on the themes from the qualitative findings. Hence, using the exploratory sequential mixed approach is considered most appropriate for the current study because the qualitative findings from the first research question were used to design the quantitative instrument for the second research question.

The exploratory mixed method design began with the document analysis of various national and global policy and research documents related to STEM education that answered the first research question. The researcher targeted countries ranking high in STEM education and were utilizing the Triple Helix components. The themes mentioned in the documents included: STEM job skills and competencies, teacher professional development and workforce demand. Yin (2011) posited that archival documents can provide support for a case, but do not tell the whole story. Therefore, the researcher used documents that were recent and varied to gain a broader understanding of the implementation and integration of STEM education programs in different countries.

According to Hanson et al. (2005), the mixed research methods help the researcher better understand the research problem by combining the trends obtained from the quantitative data and the patterns identified using the qualitative data. Additionally, the mixed research method identifies the constructs that can be studied in the future using the same or new instruments and uses the sample obtained from the quantitative data to identify the individuals that could be helpful in expanding the results and help in the better representation of the underrepresented population (Hanson et al. 2005). The data analysis process of this study followed a similar approach to build an understanding of the role of the Triple Helix model in the implementation of STEM education and supporting STEM careers. For gathering data, the researcher incorporated exploratory sequential mixed method approach. Due to the lack of research investigating the capacity of the Triple Helix model to improve STEM education and increase the number of students choosing STEM careers, it was first necessary to identify the stakeholder perspectives using questionnaires. The design of the survey included close-ended questions to address the second research questions. The participants from the university and industry clusters included students and leaders/teachers. The participants from the government cluster included Cycle 2 and Cycle 3 students, leaders/teachers and parents.

The choice of paradigm in research sets down the objective, motivation and expectations of the research under process. Therefore, proposing a paradigm at the beginning of a study creates a baseline for choosing the methodology, applied instruments, literature review and the research design (Mackenzie & Knipe 2006). Similarly, Feilzer (2010) sees paradigm "as an accepted model or pattern, as an organizing structure, a deeper philosophical position relating to the nature of social categories and social structures" (p. 7), highlighting that research is directly related by the use of a paradigm (Feilzer 2010). The researcher selected the pragmatist approach because it was the most appropriate paradigm to answer the research questions. This led to the use of the sequential mixed methods research design.

To answer a given research question, researchers are required to support the use of a methodological paradigm that carries with it its own ontological and epistemological justifications (Parvaiz, Mufti & Wahab 2016). Onwuegbuzie (2002) states that positivism dominated as a paradigm for scientific philosophy until the late nineteenth century. It was then followed by Constructivism Theory at the turn of the twentieth century (Guba & Lincoln 1994). The two approaches differ in that positivism uses primary data analysis to confirm an established theory whereas Constructivism Theory aims to develop a theory (Parvaiz, Mufti & Wahab 2016). In the 1950s, pragmatism emerged as the primary research paradigm (Onwuegbuzie & Leech 2005). With pragmatism, the researcher moves back and forth between positivism's deductive reasoning and Constructivism's inductive reasoning using 'abductive' reasoning' (Alharahsheh & Pius 2020). According to Patokorpi (2006), the abduction process is a "retroductive process (the spontaneous conjectures of instinctive reason) of finding or forming hypotheses or theories that might explain a (surprising) fact or an (unexpected) observation" (p. 73).

Charles Sanders Peirce, William James and John Dewey are recognized as the founders of pragmatism. Pragmatism is a philosophical tradition deriving from America that emphasizes the temporary nature of truth and reality that is constructed by ongoing experience (Carlsen & Mantere 2007). Cresswell and Clark (2014) point out that pragmatists believe that observations and experiences are needed to understand the single or multiple realities existing. James (1907, p. 32) considers pragmatism to be "first, a method, and second, a genetic theory of what is meant by truth". There is an objective reality, and although existing apart from human experience, it can only be accessed through human experience (Morgan 2014). As such, social construction of beliefs and habits create the basis of reality and knowledge (Yefimov 2004), although not all social constructions are made equally, and some versions can match individuals' experiences more than others (Morgan 2014). Rorty (1980) mentions that knowledge is not reality, according to pragmatism. Instead, knowledge has a purpose, and it is created to improve our lives and society (Goldkuhl 2012).

Pragmatists address issues of generalizability and transferability. Therefore, research is informed by experience and must also be useful in future experiences. Rorty (1984) highlights the perspective focused on a better future, and this attitude of social hope is one that James, a founder of pragmatism, echoes through his focus on the practical results of research in society (Martela 2015). The study collected and analyzed a variety of perceptions and experiences regarding formal and informal STEM education programs, STEM careers and the Triple Helix components. The data collected from the stakeholders was both quantitative and qualitative to gain a more comprehensive analysis of their perceptions regarding formal and informal STEM education programs, STEM careers and the role of the Triple Helix model to benefit STEM education and STEM careers in the UAE. Pragmatism's emphasis on experience to reveal reality was seen in the researcher's analysis of the participants' questionnaires. The researcher observed that formal and informal STEM education programs can be improved to make it more interesting and meaningful for students. The improvement proposed by the researcher was the use of the Triple Helix model to increase institutional collaboration between university, industry and government to support students' learning in STEM subjects.

Pragmatists are focused on the problem or research question (Mackenzie & Knipe 2006) in order to facilitate human problem-solving (Parvaiz, Mufti & Wahab 2016). The abduction process that characterizes pragmatism creates a cause-and-effect relationship that leads the researchers to reflect on the nature of the problem and conclude that acting in particular ways will likely produce a specific set of outcomes (Morgan 2014). Pragmatists consider the nature of the problem and its potential solutions (Kaushik & Walsh 2019). The researcher noticed that students do not continue the STEM pathway in higher education to pursue STEM careers. With the Triple Helix, increasing partnerships and collaborations with other institutions seemed like a promising solution since more assistance is needed to increase student engagement in STEM education. For instance, student efforts in creating innovative projects were not completed because resources were lacking to make them real. There was a need for other parties to be involved. Pragmatists also consider the nature of the potential solutions and the likely actions (Kaushik & Walsh 2019). On a general level, the researcher noticed trends in statistics detailing the growing need for employment in STEM fields. On a national level, the researcher connected the UAE's Vision 2030 to an emphasized commitment towards supporting students to pursue STEM careers for improving the economy. More research led to the discovery of the Triple Helix model, which was already being used in economics, and the researcher began thinking that the model could possibly play a role in education by improving the STEM pipeline. The Triple Helix model would bring the stakeholders together to support STEM education programs and STEM careers.

Pragmatists want to approach as many realities as possible and they assert that reality is what works. Pragmatists continuously experiment with their beliefs to create practical solutions with the focus of improving the future. Since the central focus is on 'what works' in the real world (Patton 1990), the pragmatism research paradigm supports the simultaneous use of qualitative and quantitative methods of inquiry to search for truths and to increase trustworthiness (Shaw, Connelly & Zecevic 2010). Howe (1988) underscores that claims made by pragmatists cannot be separated from habit, experiences and beliefs because truth and experience are intertwined. Therefore, any claims made by the researcher regarding formal and informal STEM education programs, future STEM careers and the Triple Helix model must derive from the experiences of the stakeholders. The literature revealed that experiences in STEM education leaves room for improvement, and the researcher's adoption of data collection methods and analysis were selected because they provided deep insight into the research questions (Creswell et al. 2003). The use of the questionnaire also allowed the researcher to accept the external realities of the stakeholders, but the analysis gave the researcher the ability to select the explanations that answered the research questions and best produced the desired results, which pragmatists are advised to do (Pansiri 2005). Since pragmatists see truth in ongoing experience (Carlsen & Mantere 2007), the interviews used in the mixed-methods research allowed the researcher to follow-up with the questionnaire participants. The participants' qualitative responses provided the researcher with more insight into the research questions because it gave a second opportunity to further develop an understanding of their perceptions. The sequential aspect of the research method was beneficial because the evaluative and analytical interview questions required the stakeholders to clarify their perceptions. The reality of STEM education is co-constructed by the participants and the researcher's analysis of the data. In addition to the emphasis on ongoing experience, pragmatists also consider experience to be open to multiple interpretations (Carlsen & Mantere 2007). The interviews opened the research to a second method for the stakeholders to share their interpretations and experiences. Data from the interviews also gave the interviewer another opportunity for analysis. In the research study, the researcher's data narratives and data collection methods centered on the experiences of the stakeholders to gain insight into the realities of STEM education, STEM careers and the Triple Helix model for promoting the UAE's Vision 2030 to create a knowledge-based society.

3.2 Research Methods

In this section, the different factors that are related to the site selection, participants, data collection, instruments and ethical consideration will be clarified. Table 3.1 demonstrates the organization of the research to present the actions and sources used to address the research questions.

RQ1: What are the common themes associated with the formal and informal STEM education programs to benefit the UAE?

RQ2: What are the perceptions of stakeholders on the formal and informal STEM education programs, STEM career choices and the Triple Helix components?

RQ3: What are the stakeholders' responses on the connections among the Triple Helix components with formal and informal STEM education programs and future STEM careers in the UAE?

Table 3.1: Summary of the organization of the study with research questions, approach, instruments, sampling and methods.

The main purpose of the study		To investigate the common themes related to the formal and informal STEM programs and stakeholders' perceptions and responses on formal and informal STEM education programs, STEM careers, and the Triple Helix model in the UAE.			
Approach		Mixed-Method			
Question	**Approach**	**Instrument**	**Sampling Technique**	**Participants**	**Data Analysis**
RQ1: What are the common themes associated with the formal and informal STEM education programs to benefit the UAE?	Qualitative	Document Analysis	Convenience Sampling	5 policy documents	Thematic Analysis
RQ2: What are the perceptions of stakeholders on the formal and informal STEM education programs, STEM career choices and the Triple Helix components?	Quantitative	questionnaire	Convenience Sampling	-Stakeholders from the governmental cycle 2 and cycle 3 public schools: 123 leaders/teachers, 361 students and 101 parents	SPSS, T-Test, ANOVA

				-Stakeholders from industries supporting STEM education: 101 students and 53 leaders/teachers -Stakeholders from university: 101 students and 54 leaders/teachers	
RQ3: What are the stakeholders' responses on the connections among the Triple Helix components with formal and informal STEM education programs and future STEM careers in the UAE?	Qualitative	semi-structured interviews	Convenienc e Sampling	-universities: 7 leaders/teachers -industries supporting STEM education: 7 leaders/teachers -government cycle 2 and cycle 3 public schools: 15 leaders/teachers	Thematic Analysis

Table 3.1 demonstrates the structure of the study that aims to find stakeholders' perceptions of formal and informal STEM education programs, STEM careers and the Triple Helix model. The study utilized the explanatory sequential mixed method research

design where the qualitative data regarding the relevant themes related to the role of the Triple Helix model improving the formal and informal STEM education programs and future STEM careers was gathered and used to create questionnaires for stakeholders. After analysing the data, the questionnaires were then used to inform the qualitative research method. In-depth interview questions were designed to focus on specific attitudes and perspectives to provide a more complete understanding of the role of the Triple Helix model in formal and informal STEM education programs and STEM careers. The interviews with stakeholders gathered more detailed information to answer the third research question. The integration of the data from both the quantitative and qualitative methods provide a UAE context-rich analysis of stakeholder perspectives that can inform educational policy makers regarding the Triple Helix model's potential influence on formal and informal STEM education programs and STEM career choices that is aligned with UAE's Vision 2030 goal to increase the STEM workforce that is based on a knowledge-based society.

3.2.1 Site/Context

Polit and Beck (2017) define the research setting as the physical context, situation and location that provide the researcher with the data. The context of this study includes participants from government, university and industry clusters. For the governmental cluster, six public schools participated from four of the emirates of the UAE including: Abu Dhabi, Sharjah, Ras al Khaimah and Dubai. The public schools all have a formal STEM program and teach middle school and high school students. The Ministry of Education designates these schools as phase 1 schools because they have only established their formal STEM programs in the recent years. Students, parents and leaders/teachers participated in the study. In the university cluster, students and leaders/teachers from three higher education institutions located in Abu Dhabi, Dubai and Ajman participated. In the industry cluster, students and leaders/teachers from five industrial institutions located in Dubai and Abu

Dhabi participated. Seeing the different perceptions of stakeholders identifies the strengths and weaknesses of each cluster, which is necessary to improve STEM education programs to better facilitate STEM careers using the Triple Helix model.

Etzkowitz and Zhou (2018) state that the Triple Helix model can lead to economic and social development through innovation, entrepreneurship, and regional focus. Additionally, the collaboration between the Triple Helix clusters breaks down boundaries between the three institutions, leading to new functions on an individual and a collective level. The researcher kept these points in mind when applying the model to education. The government and industry schools are suited to represent the Triple Helix's government and university clusters because their partnerships create new roles that support STEM educational programs for the benefit of regional development. For instance, the Alaska Adapting to Changing Environments (Alaska ACE) project focused on improving local communities' adaptive capacity to cope with environmental and social changes (Sparrow et al. 2017). This entailed involving university students, K-12 Alaskan students, educators, industry representatives and the general public in STEM learning. The innovative informal STEM learning experiences were place-based and increased the students' interest in their communities. In Indonesia and the Philippines, the Accelerated Work Achievement and Readiness for Employment (AWARE) project aimed to train a future-ready workforce. AWARE provides work-readiness training and workplace opportunities to students beginning at age 16 in the Philippines and Indonesia (WEF 2020). By providing work-readiness training and workplace opportunities, students gain valuable on-the-job experience that can support the economy.

3.2.2 Population, Sampling and Participant Selection

Cresswell (2013) clarifies that a population is distinguished from other groups by one characteristic that they possess. The researcher ensured that the participants completing the questionnaire match the population needed to meet the goals of the study (Ader 2008). The researcher used convenience sampling for the study. The study used six schools taken from the list of forty-six STEM governmental schools provided by the MOE. A convenience sample was used since the participants from the schools on the list were selected due to their availability for the study (Fraenkel & Wallen 2009). According to Johnson and Christensen (2012), convenience sampling includes the selection of individuals based on the following criteria: availability, ease of enrollment, or willingness to take part in the research study. Cresswell (2014) highlights that the participants in a convenience sample can provide useful information. For the study, an email was sent from the MOE to the six schools to complete the questionnaire. The schools contacted the stakeholders (students, parents and teachers/leaders) directly through their own communication channels so that they can obtain the link to participate in the study. For the schools in Dubai and Sharjah, the first co-ed schools listed were selected to make sure that both male and female students were represented. For the schools in Abu Dhabi and RAK, the first all-female and all-male schools from the list. By collecting questionnaires from both all-male schools, all-female schools and mixed schools, the researcher was able to collect questionnaires from the population of interest. For the parent population, the same number for the student population was used and 101 surveys were collected. For leaders/teachers, the total population was 920 and a total of 120 questionnaires were collected for the sample.

For the industry institutions supporting STEM programs, the researcher selected from institutions with partnerships with the MOE or ADEK. The participants were taken from the MOE’s 49 sponsors and ADEK’s 27 sponsors (MOE 2021; ADEK 2020). Industry institutions were defined as any informal institution that provided STEM through extra activities or provided extracurricular in STEM education programs. Eight institutions were contacted out of the 76 sponsors. These institutions were used by the researcher because the

MOE and ADEK are responsible for the informal STEM education programs, and they have affiliations with these agencies. The researcher recognized that the institutions support all students' informal STEM learning. The researcher used convenience sampling since the institutions were contacted to provide the needed information about the population rather than to be used as a representative of the population (Fraenkel & Wallen 2009).

Lastly, the university cluster population included 4920 university students and 255 university leaders/teachers. See Appendix 7 for the list of universities with STEM related programs in the UAE provided by the MOE. The researcher went over the list and contacted the universities' research departments to administer the questionnaires to the appropriate STEM departments. According to Fraenkel and Wallen (2009), a convenience sample consists of a group of individuals conveniently available to be studied (p. 106). Convenience sampling was used since the researcher accepted the responses from the universities that were willing to participate. Overall, 110 students and 54 leaders/teachers from 3 universities completed the questionnaire.

Convenience sampling was used for the interviews with the governmental schools and university participants. The government school participants were recommended by the STEM department from the MOE through a list of contacts and the university participants were contacted through the personal information they provided on the questionnaire. For the interviews with the industry participants, the researcher contacted participants who expressed interest in taking part. These various stakeholders were included in the study to answer the third research question regarding Triple Helix relationships with STEM programs. Mertens (2010) emphasizes that it is necessary for the population to include all the required components related to the study sample's criteria. To improve STEM education programs, the researcher needed to understand how the STEM program was operating in each cluster and the extent to which they are using the Triple Helix model. Since the Triple

Helix model relies on the coordination of all three components, it was important for the researcher to gather data and assess all three clusters.

Kumar (2011) explains that sampling uses a selection of individuals to represent the whole population. This indicates that to choose an effective sample, it is essential to have familiarity with the context of the study. Since the researcher was investigating the Triple Helix model, which has three components, the study needed more information about relevant populations of stakeholders in each cluster. The participants of the current study consisted of the three clusters of the Triple Helix model: government, industry and university. The sample for the government cluster included 6 schools, 123 STEM leaders/teachers, 361 middle to high school students and 101 parents. For the industry cluster, the sample included: 101 middle school to university level students and 53 leaders/teachers. For the university cluster, the sample included 110 students and 54 leaders/teachers.

3.3 Instruments

Fraenkel and Wallen (2012) define instrumentation as containing the entire process of data collection which includes the selection and design of the instruments along with the procedures and conditions involved in the administration of the instruments. Research instruments are used to measure the social phenomenon being observed (Fraenkel & Wallen 2012). They help to collect the data needed to find the solutions for the research questions (Babbie 2001). The study used the following instruments:

3.3.1 Document Analysis

According to Bowen (2009), document analysis reviews or evaluates documents, both printed and electronic, using a systematic procedure. Document analysis uses open date pieces of evidence which is helpful because they can be used with no restrictions on time or place without the need for the researcher’s intervention (Fraenkel, Wallen & Hyun 2015).

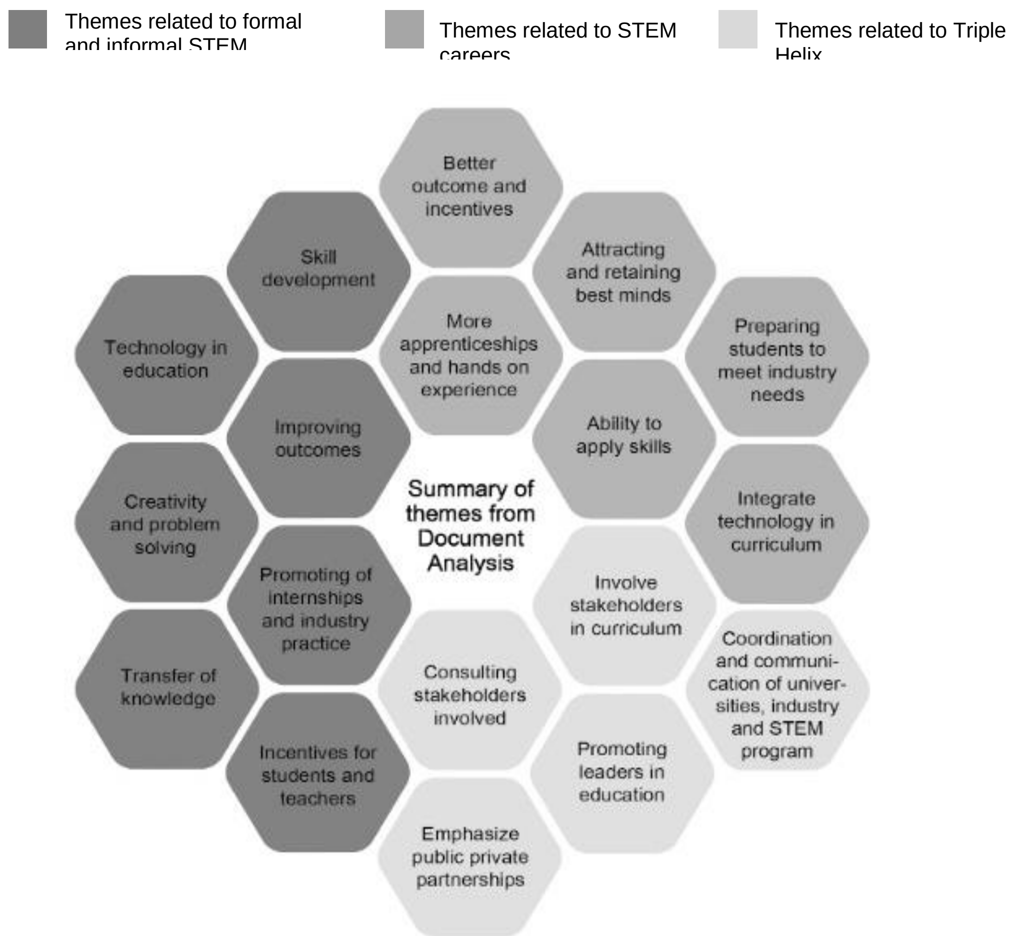
The researcher focused on the most recent available documents to answer the first research question. Also, findings across data have the impact of removing potential biases by examining information from different sources. Document analysis requires an iterative process of skimming, reading (thorough examination) and interpretation that combines elements of content analysis and thematic analysis. Regarding content analysis, information is organized into categories related to the research questions. Cresswell and Clark (2014) also highlights the necessity of clearly identifying the types of documents and their relationship to the research questions when conducting a document analysis (Creswell & Clark 2014). According to Bowen (2009), document thematic analysis of the documents was used to obtain useful information to answer the first two research questions, which interpreted international and national STEM education policies to analyze local educational policies. Braun and Clark (2006) note that document analysis is a flexible research tool that provides a detailed, complex, and nuanced account of the data.

According to Cardno (2018), the advantages of documentary analysis include: reduced cost, manageability, use of valid documents and ethical approval to access the data. The researcher compiled educational policies which were published in portals that were accessible to the public. Disadvantages of documentary analysis includes a lack of access to policy documents. The researcher faced this challenge so policy documents that were accessible and located in different geographical regions were used. Additionally, the version of the documents uploaded could be problematic since only the old versions are made available to the public. For the study, the researcher collected the most recent versions available for the policy documents. Policy documents also selectively focus on certain issues over others due to the nature of the country's political, geographical and socio-economic situation. This was noticed by the research since the policy documents from different countries used in the research study showed a variety of implementations for STEM education.

The document analysis investigated both global and local educational policies for the best implementation of STEM education programs with the components of the Triple Helix model. The five documents used were selected to establish a more expansive frame of reference. The following documents were selected due to their highlighting of STEM policy, STEM careers and the Triple Helix model. The researcher chose global policies that saw a need to improve STEM education with the collaboration between government, university and industry. Amaral (2011) mentioned that the Triple Helix model identified and contextualized the role of the actors to improve economic and social development. The STEM education policies from the US, Ireland and Australia were examined as the Organisation for Economic Co-operation and Development (OECD) ranked them as offering high-performing STEM learning environments. The ranking was based on student achievement on the Programme for International Student Assessment (PISA) and all three countries scored above the OECD average in science (OECD 2019). According to the OECD (2019), PISA scores provide an insight into a country's overall economy through the students' mean performance. The last two documents were a governmental STEM policy paper from the UAE and a STEM conference paper. The conference paper was selected because it was published recently and supports the idea that the Triple Helix, as an external factor, can help the educational system to improve and change. There is a lack of literature on the Triple Helix.

These recurring issues discussed in the documents included, but were not limited to: STEM in schools, quality issues related to advancement of STEM education, stakeholders planning for interconnectedness between sectors and partnership with community and other sectors curriculum and level of integration, STEM job skills and competencies, teacher preparation and professional development, delivery, workforce demands (see Figure 3.1). The document analysis focused on exploring the common themes regarding STEM education programs, STEM careers and the Triple Helix components. Repetition signaled importance, and the recurrent themes extracted were then translated into the topics of the question.

Figure 3.1: Summary of Themes from Document Analysis



3.3.2 Questionnaires

Questionnaires are defined as an instrument that allows the researcher to collect "self-reported data" from the participants during a part of the study (Johnson & Christensen 2012 p. 162). Questionnaires are advantageous because the quantitative component can be distributed to a vast number of people through a uniform process, and it can be easy to analyze (McMillan & Schumacher 2010). According to Cresswell and Clark (2011), survey research designs employ instruments such as questionnaires and interviews to describe trends in opinions and attitudes. The five response Likert-scale items were appropriate for the study because they helped to identify the attitudes and beliefs of individuals (Cresswell 2009).

The questionnaires were constructed by the researcher, and they helped the researcher to create conclusions about students', parents' and teachers'/leaders' perceptions regarding formal and informal STEM education programs, STEM careers and Triple Helix components. When creating the questionnaire, the researcher brainstormed categories that answered the second question. After, the researcher shared the questionnaire with two university professors. Their expertise and feedback helped the researcher to refine the statements for clarity and meaningfulness. Afterwards, the researcher made the necessary additions and modifications after studying the professors' comments and suggestions. The research targeted participants in the UAE community. Since Arabic is the mother tongue language of the participants, the questionnaire was translated to Arabic. The questionnaire was then sent to a proof-writer for further editing and translating. To ensure that the Arabic and English questionnaires were the same quality, the proof-writer used back translation, a standard translation procedure that translates text back into its original language (Dept, Ferrari, & Halleux, 2017). After making the updates, the final version of the questionnaire was piloted with one group of thirty students belonging to the industry cluster.

The questionnaire was administered to the three clusters of the Triple Helix components: government, university and industry (see Appendix 3). The questionnaire was also translated into Arabic for the government cluster (see Appendix 4). The government cluster had three questionnaires: one for leaders/teachers, parents and students. The industry and the university clusters both had two questionnaires: one for leaders/teachers and students. Section (A), the first section of the questionnaire, focused on gathering demographic information. For the student questionnaire, the demographic component was important to distinguish between female and male student perspectives. Section (B), Section (C) and Section (D) of the questionnaire focused on: the STEM education program, STEM careers and the Triple Helix components. Within the STEM program section (B), there were two subsections. The first subsection was preparing students to meet industry needs and the second subsection was skills development needed for the STEM education program. Section (B) measured stakeholders' perceptions regarding the importance of the STEM education program and the level in which it equips students for the future with 21st century skills. The STEM careers section had three subsections: better outcomes and incentives, attracting and retaining the best minds and future vision. Section (C) highlighted general perceptions about STEM careers, the information stakeholders received about STEM careers for the future and how students are being attracted towards a STEM career. The Triple Helix components had two subsections: coordination and communication among universities, industries and STEM programs and perceptions on STEM Strategy. Section (D) targeted the collaboration between the STEM program and the Triple Helix components (university, industry and government). The uniform structure of the questionnaire and the process of collecting the data from teachers/leaders, students and parents gave the researcher the ability to compare data across different participants in more than one category. See Table 3.2 for a summary of the questionnaire content.

Table 3.2: Summary of the Questionnaire content

Questionnaire Sections
Section (A) Demographic
Section (B) STEM Perceptions
Preparing Students to Meet Industry Needs
Skills Development
Section (C) Career Perceptions
Better outcomes and incentives
Attracting and retaining the best minds
Future vision
Section (D) Triple Helix Components

To administer the questionnaire, authoritative approval was necessary from the government, industry and university clusters. After approval, the questionnaire, in both English and Arabic, was emailed to the cluster leaders implementing STEM education programs. If cluster leaders were interested in participating, they sent the links to the questionnaires. During the study, the researcher contacted the cluster leaders via phone to check-in on the process of administering the questionnaires. The decision regarding when to send the surveys was left to the discretion of the cluster leaders. The benefits of a web-based survey include simplicity, low cost and increased time efficiency (Clayer & Davis 2010). Additionally, the web promotes an interactive mode of data collection and allows respondents to complete the questionnaire at their leisure. A web-based questionnaire was useful for the researcher because it didn't require direct contact during the COVID pandemic outbreak. The electronic medium also makes it easy for researchers to make adjustments, and for questions to be removed or revised (Rhodes, Bowie, & Hergenrather 2003). Web-based surveys also increase the possibility of getting in touch with hard-to-reach respondents (Monzon & Bayart 2018).

3.3.2.1 Pilot Study

According to Johnson and Chistensen (2014), reliability is defined as consistency in research results and validity is defined as the capacity of an instrument to accurately measure the variables it is designed to measure (Johnson & Christensen 2014). To test the validity and reliability of the research instrument used, Fraenkel, Wallen and Hyun (2015) recommended the use of a research pilot. A pilot study is a valuable tool as it can be used to determine if the full-scale study is feasible and guides how the researcher should proceed. It is conducted on a smaller scale, and it helps to increase the researchers' experience with the study instruments, determine the safety of treatment or interventions and recruitment potentials and examine the randomization and blinding process (In 2017). The researcher used the questionnaire from the pilot study to confirm that the instrument was able to collect the information needed to meet the goals of the research study. The researcher also wanted to guarantee that the items were relevant. Additionally, the pilot study provided the researcher the ability to determine the time needed by the sample to answer the survey questions. Fraenkel, Wallen and Hyun (2015) recommend keeping the study anonymous to promote candid responses and ensure the reliability and validity of the pilot, and the researcher followed this advice. Cronbach's alpha test is one of the most important concepts utilized in the evaluation and assessment of a questionnaire (Tavakol & Dennick 2011). Since data was gathered through a questionnaire, the researcher applied Cronbach's alpha test to add validity and accuracy to the developed instrument. Also, Bell, Whitehead and Julious (2018) suggest that the sample size for the pilot needs to be considered. As a result, the pilot study included 29 student participants, 30 teacher/leader participants and 30 parent participants to simulate the convenience sample for the study. The results of the pilot study are seen in Table 3.3.

Table 3.3: Reliability Test Result of Pilot Study

Sample Analysis: Cronbach's Alpha Reliability Statistics for the pilot study		
Cronbach's Alpha	Cronbach's Alpha Based N of Items on Standardized Items	N of Items
Total	.90	29 students
Total	.89	30 teachers/leaders
Total	.80	30 parents

3.3.3 Semi-Structured Interviews

According to Fraenkel and Wallen (2009), an interview is a kind of verbal exchange of information between people, and it aims to gather knowledge for a specific topic. The interview allows the researchers to interpret the collected information that needed more clarification by listening to extended opinions and practices (Seidman 2013). It is one of the methods that enables the researcher to discover what is behind the participants' thinking and to open their eyes to new ideas through discussion (Fraenkel et al. 2015). There are three different types of interviews. The unstructured interview is usually a conversation about a certain topic and the structured interview, like a survey interview, includes a set of standardised questions related to specific categories that need to be answered (Burns 2000). The semi-structured interview creates more opportunity for clarification and fluent thought by allowing the participant to explain in further detail their experience regarding certain topics (Smith 2003).

The semi-structured interview instrument was chosen by the researcher so that meaningful data will be derived authentically and immediately from the interviewees in a way that allows them to make sense of their experience (Seidman 2006). Furthermore, since interviews can produce a thorough understanding of the situation, interviews are considered a preferred choice for conversation (Rallis & Rossman 2012; Rubin & Rubin 2012) since they give the researcher access to a two-way discussion with the participant who are able to use their own words (Creswell 2013; Phellas, Bloch & Seale 2012). Therefore, the participant will be more proactive in their discussion (Phellas Bloch & Seale 2012). Since the research on the Triple Helix model is a new topic in STEM education, more information is needed to understand different opinions and experiences of the participants. For instance, the questionnaire touched on the different coordination and collaboration between the Triple Helix model and each of the three clusters, as well as the kind of initiatives needed from the three clusters to promote future STEM careers, but both topics needed further investigation. Melles (2005) points out that interviews help the researcher gather authentic data related to the experience of the participants better than other data collection methods.

According to Fraenkel and Wallen (2009), it is advised that the interviewers should seek out participants in different positions working in the same field to gain authentic information through various perspectives. In this research, semi-structured interviews were conducted with participants from different clusters and different positions. Leaders/teachers in the three clusters (governmental schools, university and industry) were requested to answer four open-ended questions in zoom interviews for more detailed data (see Appendix 5). The participants were 15 leaders/teachers from the government school, 7 leaders/teachers from the industry cluster and 7 leaders/teachers from the university cluster. The participants were a combination of volunteers who indicated their interest for the interview on the questionnaire. Additionally, the researcher decided to reach out to leaders in each of the clusters for voluntary discussion participants. These leaders were from organizations that originally participated in the researcher's questionnaire. The cluster leaders organized the interview time, and the researcher had no prior information regarding the participant beforehand. The questionnaire has constraints that are overcome through face-to-face conversations. More details can be gathered from the participant through the flow of conversation. Due to the pandemic, the researcher conducted the interviews using Zoom and Microsoft Teams. The interview questions were related to the three main topics in the research: the perceptions on the STEM education program, STEM careers and what is the role of the Triple Helix components in promoting formal and informal STEM education programs and STEM careers among students in middle, high, schools.

3.4 Reliability and Validity

In the following sections, an interpretation of the circumstances that threaten the reliability and validity of the research measurement instrument will be discussed. Both features, reliability and validity, are fundamental for evaluating instruments used in research.

3.4.1 Reliability

Reliability is the ability of a data collection instrument will frequently produce the same result to obtain consistently the same results when a study is repeated using the same instrument under similar conditions (Johnson & Christensen 2014; Tavakol & Dennick 2011). Using multiple methods of obtaining the data will reduce biases, increase the quality of the data which in the end will confirm the result (Denzin 2017; Golafshani 2003). Methodological triangulation was obtained by the researcher through multiple data collection methods of document analysis, questionnaires and semi-structured interviews (Creswell & Miller 2000). The researcher also used the triangulation of participants' data from each Triple Helix cluster by obtaining it from more than one source: students, parents and leaders/teachers. To enable the replicability of the study, the researcher also included a rich description for the data collection methods and the related procedures.

Reliability is defined by Creswell (2012) as the scores from measuring variables that are stable and consistent. To test the internal consistency reliability, the researcher used Cronbach's Alpha by using SPSS to measure the correlations within items to see if the items were measuring the same domain and to see how each of the items strongly or weakly relate generally to the statement. Cronbach's Alpha reliability degree of significance was calculated to measure the internal consistency of the instrument to judge the consistency of responses of the three instruments including governmental school leaders/teachers, parents and students. It was important to stand at the degree of the reliability of participants' responses to judge the consistency of their answers. In the pilot study, the Cronbach's Alpha measured over 0.7 for all participants.

First, the reliability was collected by measuring Cronbach's Alpha coefficient to assess the internal consistency of the instruments (see Table 3.4). Since the total degree and categories degree were between -1 and 1, the instrument**s** would be reliable. Effect sizes are essential for the outcome of this study as they highlight their importance to communicate the practical significance of results. In addition, 6 instruments were reported above .90, which is considered very large, and .79 was reported for industry leaders, which is considered large.

Table 3.4: Cronbach's Alpha Reliability Statistics of All the Surveys

	Leaders/Teachers	Students	Parents

	Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items
Governmental schools	.91	30	.94	29	.94	19
University	.91	30	.94	29	-	-
Industry	.79	30	.90	29	-	-

The Cronbach Alpha Coefficients were calculated for the three instruments and found of high reliability (.91, .94, .94). As shown in Table 3.5, all the clusters of governmental school leaders/teachers ranged between .65 and .87. For the clusters of governmental school students, Cronbach's Alpha Coefficients ranged between .73 and .90. Regarding the parents' survey, the Cronbach's Alpha Coefficients ranged between .78 and .92.

Overall, the Cronbach Alpha Coefficients were calculated for the two instruments regarding the university leaders/teachers and students and found of high reliability (.91, .94). As shown in Table 3.6, all the clusters of university leaders/teachers ranged between .65 and .87. For the Clusters of University students, Cronbach's Alpha Coefficients ranged between .73 and .91 (Table 3.7).

Table 3.5: Cronbach Alpha Reliability Statistics of the surveys of Governmental schools

		Leaders/Teachers		Students		Parents	
		Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items
1	Preparing students to meet	.87	5	.90	6	.86	4

	industry needs						
2	Skills Development	.83	4	.80	6	------	-----
3	Better outcomes and incentives	.65	4	.73	4	.78	6
4	Attracting & retaining the best minds	.85	3	.74	4	------	-----
5	Future vision	.76	8	.75	3	.86	3
6	Coordination and communication of universities, industry, and STEM Program	.75	6	.78	6	.92	6
	Total	.91	30	.94	29	.94	19

Table 3.6: Cronbach Alpha Reliability Statistics of the surveys of University Leaders/ Teachers & Students

		Leaders/Teachers		Students	
		Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items
1	Preparing students to meet industry needs	.87	5	.91	6
2	Skills Development	.83	4	.82	6
3	Better outcomes and incentives	.65	4	.73	4

4	Attracting and retaining the best minds	.85	3	.76	4
5	Future vision	.76	8	.75	3
6	Coordination and communication of universities, industry, and STEM Education Program	.75	6	.78	6
	Total	.91	30	.94	29

Table 3.7: Cronbach's Alpha Reliability Statistics of the surveys of Industry Leaders& Students

	Industry	Leaders/Teachers		Students	
		Cronbach 's Alpha	N of Items	Cronbach 's Alpha	N of Items
1	Preparing students to meet industry needs	.66	5	.77	6
2	Skills Development	.57	4	.73	6
3	Better outcomes and incentives	.56	4	.72	4
4	Attracting and retaining the best minds	.69	3	.76	4
5	Future vision	.83	8	.87	3
6	Coordination and communication of universities, industry, and STEM Education Program	.81	6	.91	6
		.79	30	.90	29

Regarding the semi-structured interviews, the researcher minimized participant error, researcher error, participant bias and researcher bias. To decrease participant error, the researcher allowed the interviewees to select a time for a Zoom call that was convenient for them in order to remove unnecessary obstacles to their participation. According to Fraenkel and Wallen (2009), the location is an important consideration since it may affect participant responses. To reduce researcher error, the researcher spread out the interviews over the span of three weeks, with no more than two interviews on one day. Instrument decay occurs when there is a change in the nature of the instrument, which includes the scoring procedure. One way to prevent this is to create a schedule to combat these changes (Fraenkel & Wallen 2009). To address participant bias, the researcher was transparent and made the aims of the study and the confidentiality aspect clear prior to starting the interview. The attitude of subjects also plays a role in impacting the internal validity of an instrument (Fraenkel & Wallen 2009). Lastly, researcher bias was reduced by the audio recording of the interviews. Data collectors should be aware of unconsciously distorting data. This can be circumvented by standardizing procedures (Fraenkel & Wallen 2009).

3.4.2 Validity

The validity of quantitative and qualitative approaches needs to be addressed in a mixed-method research study because the study should follow the best procedures to gather the most appropriate data for the research questions. Since including the Triple Helix model into STEM education is a new topic, the researcher started with an exploratory process to ensure the validity of the questionnaire. To establish the validity of the questionnaire and semi-structured interviews, the researcher did the following:

Face Validity: To establish face validity, the researcher checked to see if the questionnaire appeared to measure what it claimed to measure. The researcher showed the questionnaire to two university professors and three family members who are unrelated to the educational system to evaluate the understandability and meaning of the questions (Gravetter & Forzano 2012).

Content Validity: Content-related validity refers to the assessment of the content and format of the instrument to measure indicators of the concept it is measuring (Drost 2011). Obtaining content validity relies on the judgement of experts who are knowledgeable about what is going to be measured (Fraenkel, Wallen & Hyun 2015). Accordingly, the researcher shared the initial questionnaire with two university professors one from the education department and the second from the business department, for feedback regarding its comprehensibility. Both professors have experience in research and publishing. Based on the professors' recommendations, a few questions were modified. Additionally, the questionnaire was then sent to a proofreader to make sure that the content was understandable and for a translation since the questionnaire would be administered in both English and Arabic. For the semi-structured interview questions, two professors, my supervisor for my doctoral program and a professor with business consulting experience, and a cycle 2 administrator, a vice principal of seven years with thirteen years of experience as a math teacher, were contacted to check the structure of the questions. Also, the researcher enlisted the expertise of the same professors and a translator, with ten years of experience, to evaluate and review the questionnaire and interview questions for relevancy to the research questions, accuracy and precision of language, clarity of expression and cultural sensitivity to the Emirati context. The content validity of the quantitative research instrument questionnaire was done through professional reviews by professors and a translator, discussions with peers in the educational field and pilot testing (Almanasreh, Moles, & Chen 2019). For the content validity of the qualitative data in the questionnaire, the researcher considered the uniformity and wording of interview questions as provided by professional feedback (Cannel & Khan 1968). For both quantitative and qualitative components of the study, the researcher also used constructive listening and seeking feedback for clarity to increase credibility of feedback (Walcott 1994).

3.5 Data Analysis

The purpose of analyzing data is to create generalizations and come to logical conclusions (Merriam 1988, p. 139). According to Rossman and Rallis (1998), data analysis is a continuous process that has no specific beginning since the researcher moves forward through reflecting on the unfolding data. As a result, data analysis provides structure to the study (Marshall & Rossman 1999).

The data collected in the research included: document analysis regarding STEM education, STEM career perceptions and the Triple Helix model with STEM education, questionnaire surveys from stakeholders in all three components of the Triple Helix model and voluntary semi-structured interviews with stakeholders. This exploratory sequential mixed method approach examined the role of the Triple Helix model to improve STEM education programs and STEM careers. Data was analysed quantitatively and qualitatively to address the research questions.

To address the first research question, the researcher collected education policies from countries with students excelling in STEM education programs and/or have a high percentage of students pursuing STEM careers. Educational policies from the UAE were also examined simultaneously as all documents were interpreted to find common themes. Cardno (2018) indicates that policy document analysis is a research tool in qualitative research projects that can be used in educational problems. The researcher selected this method because documentary analysis lends itself to a multi-method form of triangulation that increases rigor to a study. Repeated concepts found in the documents became the themes investigated in the survey questionnaire. The more a concept appears, the more reasonable it is to be a theme, but it is an investigator's decision as to how many repetitions it requires (Ryan & Bernard 2003). The researcher considered a repetition of four or more times to constitute a theme. When analyzing content, an inductive or deductive approach can be taken. The researcher used the inductive approach in order to extract themes and categories through coding the text. Annotation during close reading and re-reading of the policy documents allowed the researcher to structure categories from the raw data (Cardno 2018). The researcher examined and analysed the STEM policy documents to gather frequent themes about STEM education, STEM career perceptions and the Triple Helix model with STEM education.

To address the second research question, the researcher analysed the responses of students, teachers, leaders and parents from the questionnaire survey to explore the stakeholder perceptions on STEM education programs, STEM careers and the Triple Helix components. The researcher applied Descriptive Statistics of Mean and the Standard Deviation (see Table 3.8), the Degree benchmarks suggested by Cohen, Manion and Morrison (2013), Cronbach's Alpha by using SPSS, Independent Sample T-Test 2 variables, One Way ANOVA and Multiple Comparisons Analysis to reach the concluding points.

Table 3.8: Criteria for Measure of the Degree Responses

Degree	**Mean**
Very Low	1-1.79
Low	1.80-2.59
Medium	2.60-3.39
High	3.40-4.19
Very High	4.20-5.00

To address the third research question, used semi-structured interviews. The interviews were conducted in both English and Arabic. Arabic interviews were translated into English and transcribed to a word document. The researcher listened to the audio twice to ensure accuracy of the answers. A thematic approach was used by the researcher to look for themes in the data. The researcher approached the data without any predetermined codes, instead, the codes were created through the re-readings of the transcripts. Coding helps organize the information into main ideas (Clark & Creswell 2015; Cohen, Manion & Morrison 2013; Creswell 2014). To analyze and find themes within the data, the researcher used thematic analysis and applied six steps of Braun and Clarke's (2006) strategy.

3.6 Ethical Considerations

To protect the participants and to maintain the ethics of the research study, ethical considerations were carefully observed during the research study. The researcher followed the ethical code of conduct as outlined by BUID. To conduct research, the researcher first sent the research approval letter for collecting data to the institutional leaders or research departments for the distribution of the questionnaire. For the semi-structured interviews, a consent form was given to the participants (see Appendix 6). The interviews were scheduled during times that were convenient to the participants. The researcher was ready to answer any questions or concerns posed by the participants during the interviews. In doing so, the researcher aimed to ensure that the participants were aware of the research's features to increase their feelings of comfort and ease (Fraenkel & Wallen 2009). The interview questions that were answered in Arabic were translated into English by a professional translator. The use of a professional translator's expertise increased accuracy of the translation.

The researcher also fulfilled the ethical requirements of the study by including an introductory section that explained the research study and its purpose in each research instrument (the questionnaire and the interview). During the interviews, the researcher discussed with the interviewees the purpose of the study, explained the content of their informed consent, showed an openness to receive and answer questions and provided reassurance that their concerns would be addressed (Fraenkel & Wallen 2009). The participants were also informed that they could withdraw from the study at any time and that the collected data would remain confidential and used only for research purposes. All the data involved in the study such as the interview recordings and the interview notes and coding were securely stored in a locked folder. Pseudonyms were also used for the participants.

CHAPTER 4: Results and Findings

This chapter presented the analyses and interpretations of the data collected from the participants of the current study. This research aimed to investigate the common themes related to the formal and informal STEM education and stakeholders' perceptions and responses on formal and informal STEM education programs, STEM careers and the Triple Helix in the UAE. The study, which was a multiphase approach, has its own data analysis and interpretation. The researcher first conducted a document analysis of various policy documents related to STEM education programs to answer the first research question. During this first phase, the researcher used policy documents that dealt with the implementation and integration of formal and informal STEM education programs in different countries. The document analysis protocol (Appendix 7) adapted an instrument created by Ortiz, Locks and Olson (2016). Merriam (2009) also advises to accurately determine a document's location and authenticity. As a result, the document protocol includes the following elements: document type, document title, document source, document author, document objective, and the research question it helps to answer. The common themes found among these documents were used to create the close-ended and open-ended questions in the questionnaire for the second phase of the study.

The second phase of this study included two steps, during which the second and third research questions were addressed. In the first step, the survey investigated the perceptions of the stakeholders (leaders, teachers, students, parents) from the three Triple Helix clusters. The second step consisted of follow-up semi-structured interviews to obtain more detailed data.

The research questions are listed below:

RQ1: What are the common themes associated with the formal and informal STEM education programs to benefit the UAE?

RQ2: What are the perceptions of stakeholders on the formal and informal STEM education programs, STEM career choices and the Triple Helix components?

RQ3: What are the stakeholders' responses on the connections among the Triple Helix components with formal and informal STEM education programs and future STEM careers in the UAE?

4.1 Results for Research Question 1

To answer the first research question, the researcher used thematic analysis to analyse the policy documents. By using thematic analysis, patterns in the data can be identified, analysed and reported (Braun & Clark 2006). The purpose of document analysis was to identify themes from various documents on STEM education implementation and integration policy from different countries to benefit the STEM program in the UAE. Patton (2002) outlines the six steps of thematic analysis as follows: "(a) familiarising oneself with the data; (b) generating initial codes; (c) searching for themes; (d) revising themes; (e) defining and naming themes; and (f) producing the report."

Step 1

In the first step of thematic analysis, familiarity with the data began with the researcher creating a Microsoft Word document for taking notes on the policy documents. After reviewing each policy document, the researcher created reflection entries to capture associations and similarities (Yin 2015) that related to the first research question. See Table 4.1 for a list of the policy documents.

Table 4.1: Summary of Documents

N	Document Title	Document Summary	Source and author
1	Science, Technology & Innovation Policy in the United Arab Emirates	Emphasis on science, technology and innovation as drivers for sustainable development	UAE Government (2015)

2	STEM Education Policy Statement 2017-2026 (Dublin*)*	Objectives for achieving and improving the STEM education experience and outcomes for all learners.	Bruton, R. (2017)
3	Challenges in STEM Learning in Australian Schools	Focuses on student outcomes, the teacher workforce and the curriculum related to STEM	Timms et al. (2018)
4	Charting a Course for Success: America's Strategy for STEM Education	Action steps for a nationwide collaborative effort to support STEM education for long-term improvement	Committee on STEM Education (2018)
5	What can Career & Technical Education and STEM Practitioners in the Gulf Region Learn from Practitioners in the United States?	Takes the lessons on collaboration from the US Career and Technical Education (CTE) to benefit GCC students through implementation	Williams, J. (2016)

Step 2

The second step of thematic analysis related to creating initial codes in MS Word. The initial codes highlighted features of the policies related to STEM education, STEM careers and the Triple Helix that would be pertinent to STEM education in the UAE. These codes gave the researcher a way to arrange the discoveries and sort through the recurring ideas in the policy documents. A yellow highlighter was used in all the documents to highlight key phrases related to STEM education, a green highlighter was used for STEM careers, and a blue highlighter was used for the Triple Helix. Additionally, the lines or paragraphs that depict data relevant to the research question and/or study's purpose were underlined in red. Meanwhile, reflections on potential patterns and codes were written in the margins.

Step 3

During the third step of thematic analysis, the relationship between the initial codes were used to create initial themes that related to the first research question. Boundaries were also created so that the goals of the study were being reflected in the coded extracts from the policy documents. Journal entries were made to document the codes-themes relationships that were supported by the policy documents.

Step 4

In the fourth step of thematic analysis, the researcher reviewed the initial themes so that they were distinct from each other and aligned with the research question and the goals of the study. The themes were checked to see if they were supported by the policy documents. It was important for the researcher to check the strength of the analysis by reviewing the data to see if they matched the codes and to reassess the themes to ensure that they are directly supported by the codes.

Step 5

In the fifth step of thematic analysis, an ongoing analysis helped the researcher to refine and define the themes through organising, clustering and identifying the relevancy of the themes to the research question and the purposes of the studies. The researcher once again checked to ensure that the themes were supported by most of the policy documents. The themes that emerged were themes related to STEM and education policy, themes related to career and themes related to the Triple Helix model and STEM.

Step 6

In the final step of thematic analysis, the researcher wrote the "Discussion" section in chapter 5 of the study. The researcher ensured that the themes would be reflected in the answers to the research questions. Table 4.2 provides the complete list of the three final themes and the coded features of the policy documents that support it.

Table: 4.2 Summary of Themes and Codes from Document Analysis

<table>
<tr><th>Organizing Theme 1: Themes related to Formal and Informal STEM Education Programs</th><th>Organizing Theme 2: Themes Related to STEM Careers</th><th>Organizing Theme 3: Themes Related to the Triple Helix, STEM Education Programs and STEM Careers</th></tr>
<tr><td colspan="3" align="center">Codes</td></tr>
<tr><td>• Technology in Education
• Creativity and Problem Solving
• Transfer of Knowledge
• Skills Development
• Improving Outcomes
• Promoting of Internships and Industry Practice
• Incentives for Students and Teachers</td><td>• Better Outcome and Incentives
• More Apprenticeships and Hands on Experience
• Attracting and Retaining the Best Minds
• Ability to Apply Skills
• Preparing Students to Meet Industry Needs
• Integrate Technology in Curriculum</td><td>• Consulting Stakeholders Involved
• Emphasize Public Private Partnerships
• Involve Stakeholders in Curriculum
• Promoting Leaders in Education
• Coordination and Communication of Universities, Industries and Schools</td></tr>
<tr><td colspan="3">Document Title: Science, Technology & Innovation Policy in the United Arab Emirates
Type of document: Federal Policy paper
Source and author: UAE Government (2015)
Topic: STEM Skills

Themes related to Formal and Informal STEM Education Programs
• Focus on strong STEM skills development in all school years to achieve excellent education outcomes
• Attract and retain the best STEM minds
• Need of a STEM culture that encourages and rewards
• Incorporate technology in STEM education
Themes Related to STEM Careers
• 21st century skills are critical
• More focus on sustainability and the environment
• Emphasis on the responsibility of the individual to others
Themes Related to the Triple Helix, STEM Education Programs and STEM Careers</td></tr>
</table>

- Integrating science, business and technology (inputs and investments from different sectors)
- Creating a culture of innovation among individuals, firms, and the public sector

Document Title: STEM Education Policy Statement 2017-2026 (Dublin: Department of Education and Skills)
Type of document: Policy Document
Source and author: Bruton, T. (2017)
Topic: PPP in Education/ Curriculum Development

Themes related to Formal and Informal STEM Education Programs
- Update curricula by reducing bureaucracy
- Incorporate the use of information technology in STEM classrooms
- Instructional materials develop critical thinking and problem-solving skills

Themes Related to STEM Careers
- Knowledge between experts from the private sector to government agencies needs to be transferred
- Training and developing employees on the management and operation of projects

Themes Related to the Triple Helix, STEM Education Programs and STEM Careers
- Public-Private Partnerships (PPPs) in education maximize the potential for increasing equitable access to schooling
- PPPs improve education outcomes
- Creating a national body that is able to develop and revise the national curriculum (include input of external actors)
- PPPs can result in research investments

Document Title: Challenges in STEM Learning in Australian Schools
Type of document: Literature and Policy Review
Source and author: Timms et al. (2018)
Topic: STEM Learning, Communication between university and industry and motivation

Themes related to Formal and Informal STEM Education Programs
- Enhancing the quality of student learning in STEM by raising expectations
- Engagement, participation and ability in STEM classes needs to be increased
- Promote student development of innovative solutions

Themes Related to STEM Careers
- Increasing students' and stakeholders' STEM awareness

Themes Related to the Triple Helix, STEM Education Programs and STEM Careers
- Building connections between schools and industries facilitates effective partnerships

Document Title: Charting a Course for Success: America's Strategy for STEM Education
Type of document: Policy Document
Source and author: Committee on STEM Education (2018)
Topic: STEM careers, Professional Development, 21st Century Skills, Universities and Innovation

Themes related to Formal and Informal STEM Education Programs
- Develop flexible and dynamic learning spaces for students to
- develop identities and interests in science

Themes Related to STEM Careers
- Develop flexible and dynamic learning spaces for students to develop identities and interests in science (student-centric model of education)
- Teachers must participate in professional development.
- Students' skills should be expanded outside education and into the workplace with training on 'soft skills' (i.e., time management, collaboration skills, etc.)

Themes Related to the Triple Helix, STEM Education Programs and STEM Careers
- Joint projects between local universities and industry needed (i.e., research grants)
- Incentives given to university faculty members who develop relationships with outside organizations

- School leaders should promote parental engagement

Document Title: What can Career & Technical Education and STEM Practitioners in the Gulf Region Learn from Practitioners in the United States?
Type of document: Fall 2016 ASEE Mid-Atlantic Regional Conference Paper
Source and author: Williams, J. (2016)
Topic: STEM curriculum and STEM careers

Themes related to Formal and Informal STEM Education Programs
- Quality of instruction is a priority
- Curricula needs to incorporate project-based and student-centered learning

Themes Related to STEM Careers
- Students need to be prepared for postsecondary success

Themes Related to the Triple Helix, STEM Education Programs and STEM Careers
- Stronger alignment between school and work can be achieved by partnerships between local universities and industries

4.2 Quantitative Data Analysis Results for the Research Questionnaire

In this section, the results of the perceptions of stakeholders from the government cluster (leaders/teachers, students and parents), industry cluster (leaders/teachers and students) and university cluster (leaders/teachers and students) are presented the researcher used Descriptive Statistics of Mean and the Standard Deviation with criteria of degree responses including very low, low, medium, high and very high (see Table 3.8). The researcher also used Cronbach's Alpha by using SPSS, Independent Sample T-Test 2 variables, One Way ANOVA and Multiple Comparisons Analysis for analysis. The results answer the second research question: What are the perceptions of stakeholders on the formal and informal STEM education programs, STEM career choices and the Triple Helix components?

4.2.1 Results of Demographic Data Analysis

The participants of the current study consisted of the three clusters of the Triple Helix model: government, industry and university. The sample for the government cluster included 6 schools with 123 STEM teachers and leaders participating. In the government schools, the participant came from four emirates (Abu Dhabi, Dubai, Sharjah and Ras Al Khaimah) with 44.7% of the teacher/leader participants coming from Abu Dhabi, 12.2%

from Dubai, 29.3 from Sharjah and 13.8% from Ras Al Khaimah. The total number of parent participants was 101, with 45% of the parents having a child enrolled in middle school and 56% parents with a child in high school. The total number of participating students was 361 and 69.3% of the total participants were female and 30% of the total participants were males (see Table 4.3: Table 4.5).

In the industry cluster, the participants came from four emirates (Abu Dhabi, Dubai, Sharjah and Ras Al khaimah). There were a total number of 53 teachers/leader participants with 56.5% coming from Abu Dhabi, 32.1% from Dubai, 5.7% from Sharjah and 5.7% from Ras Al Khaimah. The total number of participating students were 101, with a total number of 61 female participants (representing 60.4% of the total number of participants) and a total number of 40 male participants (representing 39.6% of the total number of participants) (see Table 4.6 & Table 4.7).

In the university cluster, the participants came from three emirates (Abu Dhabi, Dubai and Ajman). The total number of teachers and leaders who participated was 54 with 16.7% coming from Abu Dhabi, 7.4% from Dubai 7.4% and 75.9% from Ajman. The total number of participating students was 110 and the total number of the female participants was 57 which represented 51.8% of the total number of the male participants were 53 which represented 48.2 % of the student population (see Table 4.8 & Table 4.9).

Table 4.3: Demographic Description of Governmental School Leaders/ Teachers

Location Emirates	Frequency	Percentage
Abu Dhabi	55	44.7
Dubai	15	12.2
Sharjah	36	29.3
Ras Al khaimah	17	13.8

Total	123	100
Academic Grade Levels under the Supervision of Governmental School Leaders and Teachers		
Middle School	45	36.6
High School	62	50.4
Leaders out of School	16	13
Total	123	100

Table 4.4: Demographic Description of Governmental School Parents

Location Emirates	Frequency	Percentage
Abu Dhabi	26	25.8
Dubai	6	5.9
Sharjah	27	26.7
Ras Al khaimah	42	41.6
Total	101	100
Academic Grade Level of Governmental Parent’s Child		
Middle School	45	44.6
High School	56	55.4
Total	101	100

Table 4.5: Demographic Description of Governmental School Students

Location Emirates	Frequency	Percentage
Abu Dhabi	32	8.9
Dubai	70	19.4
Sharjah	138	38.2
Ras Al khaimah	121	33.5
Total	361	100

Student's Gender		
Male	111	30.7
Female	250	69.3
Middle school	98	27.1
High school	263	72.9
Students Intention of Attending University		
Yes	255	70.6
No	11	3
Undecided	95	26.3
Total	361	100
Students Intending to Pursue STEM Fields in the Future		
Science	50	13.9
Technology	49	13.6
Engineering	93	25.8
Math	15	4.2
Others	154	42.7
Total	361	100

Table 4.6: Demographic Description of Industry Leaders and Teachers

Location Emirates	Frequency	Percentage
Abu Dhabi	30	56.5
Dubai	17	32.1
Sharjah	3	5.7
Ras Al khaimah	3	5.7
Total	53	100
Academic Grade Levels Under the Supervision of Industry Leaders and Teachers		

Middle School	9	17
High School	14	26.4
After School Stem program	30	56.6
Total	53	100

Table 4.7: Demographic Description of Industry Students

Location Emirates	Frequency	Percentage
Abu Dhabi	41	40.6
Dubai	26	25.7
Sharjah	25	24.8
Ras Al khaimah	9	8.9
Total	101	100
Student's Gender		
Male	40	39.6
Female	61	60.4
Total	101	100
Undergraduate	67	66.4
Cycle 2 and Cycle 3	27	26.7
Others	7	6.9
Total	101	100
Intention of Attending University		
Yes	90	89.1
No	8	7.9
Undecided	3	3
Total	101	100
Students Intending to Pursue STEM Fields in the Future		
Science	25	24.8

Technology	25	24.8
Engineering	33	32.7
Math	5	5
Others	13	12.9
Total	101	100

Table 4.8: Demographic Description of University Leaders and Teachers

Location Emirates	Frequency	Percentage
Abu Dhabi	9	16.7
Dubai	4	7.4
Ajman	41	75.9
Total	54	100
Program Type		
In Compass STEM program	50	92.6
Summer STEM program	1	1.9
Other	3	5.6
Total	54	100

Table 4.9: Demographic Description of University Students

Location Emirates	Frequency	Percentage
Abu Dhabi	49	44.5
Dubai	16	15.5
Ajman	44	40
Total	110	100
Student's Gender		
Male	53	48.2

Female	57	51.8
Total	110	100
Academic Degree		
Undergraduate	78	70.9
Graduate	32	29.1
Total	110	100
Program Type		
In compass STEM program	35	31.8
Summer STEM program	22	20
Others	53	48.2
Total	110	100
Students Intending to Pursue STEM Fields in the Future		
Science	29	26.4
Technology	13	11.8
Engineering	62	56.4
Math	1	.9
Others	5	4.5
Total	110	100

4.2.2 Participants' Perceptions towards Formal and Informal STEM Education Programs

The first part of this section (Tables 4.10 – 4.16) presents the perceptions of the leaders and teachers in governmental schools, universities and industrial institutions on the formal and informal STEM programs. The responses of students include two clusters: *Preparing Students to Meet Industry Needs and Skills Development* while others' responses include only *"Preparing Students to Meet Industry Needs".* The second part of this section

(Tables 4.17 – 4.25) holds comparisons among the perceptions of the three stakeholders (leaders and teachers, students and parents in governmental schools, universities and industrial institutions) on the formal and informal STEM programs' influence on career choices including three clusters: *Better Outcomes and Incentives, Attracting and Retaining the Best Minds and Future Vision.* This section also tackles gender comparison between genders and stakeholders to show the big picture. Analysis of participant perceptions include within clusters.

Table 4.10: Descriptive Statistics of Governmental School STEM Leaders'/Teachers' Perceptions on the Science Based (Science, Technology, Engineering and Maths) STEM program (Preparing Students to Meet Industry Needs). (N =123)

Variable	Mean	SD	Degree
2.1 The current STEM program is important for students.	4.33	.607	Very High
2.2 The current STEM curriculum is able to prepare students to meet future industrial needs.	4.24	.702	Very High
2.4 Problem solving strategies always take an important part in the current STEM program.	4.21	.631	Very High
2.5 Professional development for teachers is an effective part of the current STEM program.	4.20	.720	Very High
2.3 Students always show hands-on practices in the current STEM program.	4.08	.708	High
Cluster 1 Total	4.21	.546	Very High

Table 4.10 shows that the degree of governmental school leaders' and teachers' perceptions towards preparing students to meet industry needs was reported very high in 4 items of this cluster and one is high. The mean score of all items of this cluster ranged between 4.33 and 4.08. The total mean score was 4.21 of the whole cluster.

Table 4.11: Descriptive Statistics of Governmental School Students' Perceptions on the science based (Science, Technology, Engineering and Maths) STEM program. (N =361)

Cluster	Variable	Mean	SD	Degree

Preparing Students to Meet Industry Needs	2- My current STEM curriculum will prepare me for future industrial needs.	3.68	.967	High
	1- It is clear why my current STEM program is important.	3.64	1.03	High
	5- The STEM program is easier to learn with my current STEM instructor/teacher.	3.60	1.025	High
	3- The STEM subjects (Science, Technology, Reading, Engineering, Art and Maths) can be learned effectively through practical activities.	3.52	.940	High
	6 I like the current STEM program I am a part of.	3.42	1.048	High
	4- I have the ability to easily solve problems by using STEM strategies.	3.40	.984	High
	Custer 1 Total	3.54	.706	High
Skills Development	9- I use modern technology in my current STEM activities.	3.88	.937	High
	8- I learn STEM by collaborating with other students.	3.80	1.027	High
	7 -My current STEM program requires effective speaking and writing skills.	3.77	.925	High
	12 -My current STEM program can solve problems related to the world effectively.	3.60	.956	High
	11- I learn how to break down large projects in a step-by-step process in my current STEM program.	3.57	1.04	High
	10- I learn skills to solve problems effectively in my current STEM program.	3.51	1.01	High
	Custer 2 Total	3.69	.75	High
	Total Mean of the two clusters	3.62	.658	High

Table 4.11 shows that the degree of governmental students ' perceptions towards *Preparing Students to Meet Industry Needs* was reported high in 7 items of this cluster. The mean score of all items of this cluster ranged between 3.68 and 3.40. The total mean score was 3.54 of the whole cluster. Table 4.11 also shows that the degree of governmental school students' perceptions towards *Skills Development* was reported high in 6 items of this cluster. The mean score of all items of this cluster ranged between 3.88 and 3.51. The total mean score was 3.69 of the whole cluster. The total average mean score of the two clusters was 3.62.

Table 4.12: Descriptive Statistics of Governmental School STEM Parents' perceptions on the science based (Science, Technology, Engineering and Maths) STEM program (Preparing Students to Meet Industry Needs) (N =101)

Variable	Mean	SD	Degree
1- Joining the current STEM program is important for my (son/daughter).	3.94	.988	High
4- I am satisfied with my (son/daughter)'s STEM teachers' ability to teach the STEM curriculum.	3.83	.960	High
2- The current STEM curriculum sufficiently prepares my (son/daughter) for future career needs.	3.76	.95	High
3- My (son/daughter) is passionate about the current STEM program.	3.58	1.07	High
Cluster1 Total	3.78	.829	High

Table 4.12 shows that the degree of governmental school STEM parents' perceptions on the science based (Science, Technology, Engineering and Maths) STEM program *(Preparing Students to Meet Industry Needs* was reported high in 4 items of this cluster. The mean score of all items of this cluster ranged between 3.94 and 3.58. The total mean score was 3.78 of the whole cluster.

Table 4.13: Descriptive Statistics of Industry Leaders'/ Teachers' Perceptions on the Science Based (Science, Technology, Engineering and Maths) STEM program (Preparing Students to Meet Industry Needs). (N =53)

	Mean	SD	Degree
1- The current STEM-related program is important for students.]	4.72	.601	Very High
4- Problem solving strategies always take an important part in the current STEM-related program.]	4.49	.697	Very High
3- Students always show hands-on practices in the current STEM-related program.]	4.32	.779	Very High
5- Professional development for teachers is an effective part of the current STEM-related program.]	4.28	.841	Very High
2- The current STEM-related program is able to prepare students to meet future industrial needs.]	4.02	.747	High
Cluster 1 Total	4.37	.482	Very High

Table 4.13 shows that the degree of industry leaders' perceptions towards *Preparing Students to Meet Industry Needs* was reported very high in 4 items of this cluster and one is

high. The mean score of all items of this cluster ranged between 4.72 and 4.02. The total mean score was 4.37 of the whole cluster.

Table 4.14: Descriptive Statistics of Industry STEM Students' Perceptions on the Science Based (Science, Technology, Engineering and Maths) STEM program. (N =101)

	Variable	Mean	SD	Degree
Preparing Students to Meet Industry Needs	3- The subjects related to STEM (1, 2, 3, and Maths) can be learned effectively through practical activities.]	4.24	.885	Very High
	1- It is clear why my current program (which is related to STEM) is important.]	4.09	.838	High
	2- My current curriculum (which is related to STEM) will prepare me for future industrial needs.]	4.03	.888	High
	4- I have the ability to easily solve problems by using strategies used in STEM (1, 2, 3, and Maths) related subjects.]	3.93	.897	High
	5- My program (which is related to STEM) is easier to learn with my current instructor/teacher.]	3.77	1.085	High
	6- I like the current program (which is related to STEM) that I am a part of.]	3.73	1.157	High
	Cluster 1 total	3.97	.656	High
Skills Development	3- I use modern 2 in my current STEM-related program.]	4.14	.895	High
	1- My current program (which is related to STEM) requires effective speaking and writing skills.]	4.07	.886	High
	6- My current program (which is related to STEM) requires solving problems related to the world effectively.]	4.04	.871	High
	4- I learn skills to solve problems effectively in my current program (which is related to STEM).]	3.92	.987	High
	5- I learn how to break down large projects in a step-by-step process in my current program (which is related to STEM).]	3.83	.981	High
	2- I learn my subject (which is related to STEM) by collaborating with other students.]	3.80	.970	High
	Cluster 2 Total	3.97	.608	High

Total of both clusters	3.97	.570	High

Table 4.14 shows that the degree of industry students' perceptions towards *Preparing Students to Meet Industry Needs* was reported very high in 1 item of this cluster and 5 items were high. The mean score of all items of this cluster ranged between 4.24 and 3.73. The total mean score was 3.97 of the whole cluster. Table 4.14 also shows that the degree of industry students' perceptions towards *Skills Development* was reported high in 6 items. The mean score of all items of this cluster ranged between 4.14 and 3.80. The total mean score was 3.97 of the second cluster and the average mean score is also the same.

Table 4.15: Descriptive Statistics of University Leaders'/ Teachers' Perceptions on the Science Based (Science, Technology, Engineering and Maths) STEM Program (Preparing Students to Meet Industry Needs). (N =54)

	Mean	**SD**	**Degree**
1- The current STEM program is important for students.]	4.50	.666	Very High
4- Problem solving strategies always take an important part of the current STEM program.]	4.22	.691	Very High
2- I am satisfied with the current STEM curriculum to prepare students for future industrial needs.]	4.15	.656	High
5- Professional development for leaders/educators is an effective part of the current STEM program.]	4.11	.744	High
3- Students always show hands-on practices in the current STEM program.]	4.09	.734	High
Theme1	4.22	.521	Very High

Table 4.15 shows that the degree of university leaders' and teachers' perceptions on the science based (Science, Technology, Engineering and Maths) STEM program industry leaders' perceptions towards preparing students to meet industry needs was reported very high in 2 items of this cluster and 3 items were high. The mean score of all items of this cluster ranged between 4.50 and 4.09. The total mean score was 4.22 of the whole cluster.

Table 4.16: Descriptive Statistics of University Students' Perceptions on the Science Based (Science, Technology, Engineering and Maths) STEM program. (N =110)

		Mean	SD	Degree
Preparing Students to Meet Industry Needs	[2.3- The subjects related to STEM (Science, Technology, Engineering, and Maths) can be learned effectively through practical activities.]	4.24	.928	Very High
	[2.1- It is clear why my current program (which is related to STEM) is important.]	4.21	.779	Very High
	[2.4- I have the ability to easily solve problems by using strategies used in STEM (Science, Technology, Engineering and Maths) related subjects.]	4.00	.835	High
	[2.6- I like the current program (which is related to STEM) that I am a part of.]	3.98	1.040	High
	[2.2- My current curriculum (which is related to STEM) will prepare me for future industrial needs.]	3.93	.974	High
	[2.5- My program (which is related to STEM) is easier to learn with my current instructor/teacher.]	3.68	1.083	High
	Cluster 1 total	4.00	.661	High
Skills Development	[3.1- My current program (which is related to STEM) requires effective speaking and writing skills.]	4.20	.776	Very High
	[3.3- I use modern technology in my current STEM-related program.]	4.08	.949	High
	[3.6- My current program (which is related to STEM) requires solving problems related to the world effectively.]	4.03	.883	High
	[3.4- I learn skills to solve problems effectively in my current program (which is related to STEM).]	3.95	.966	High
	[3.2- I learn my subject (which is related to STEM) by collaborating with other students.]	3.85	1.003	High
	[3.5- I learn how to break down large projects in a step-by-step process in my current program (which is related to STEM).]	3.85	1.024	High
	Cluster 2 Total	3.99	.665	High
	Total of the 2 clusters	4.00	.613	High

Table 4.16 shows that the degree of university students' perceptions towards *Preparing Students to Meet Industry Needs* was reported very high in 2 items and 4 items

were high in the cluster of *Preparing Students to Meet Industry Needs*. The mean score of all items of this cluster ranged between 4.24 and 3.68. The total mean score was 4.00 of the whole cluster. Table 4.16 also shows that the degree of university students' perceptions towards *Skills Development* was reported very high in 1 item and 5 high in other 5 items. The mean score of all items of this cluster ranged between 4.20 and 3.85. The total mean score was 3.99 of the second cluster and the average mean score was also 4.00.

4.2.3 Summary of the Participants' Perceptions towards Formal and Informal STEM Education Programs

To sum up the results of this section about participants' perceptions towards *Preparing Students to Meet Industry Needs* and *Skills Development*, the degrees of most participants' perceptions were reported in the category "High" except for three types of perceptions were in the category "Very High" e.g. governmental school leaders'/teachers' perceptions; industry leaders'/teachers' perceptions; and university leaders'/ teachers' perceptions on the science based (Science, Technology, Engineering and Maths) STEM program (*Preparing Students to Meet Industry Needs*).

4.2.4 Participants' Perceptions towards Future STEM Careers

The next section (Tables 4.17 – 4.23) tackles the perceptions of the three stakeholder clusters, leaders and teachers, students and parents in governmental schools, universities and industrial institutions on the formal and informal STEM programs and their influence on career choices including three clusters: *Better Outcomes and Incentives, Attracting and Retaining the Best Minds and Future Vision*. Analysis of participant perceptions include within clusters.

Table 4.17: Descriptive Statistics of Governmental School Leaders' Perceptions towards STEM Careers and Career Interests (N =123)

	Variable	Mean	SD	Degree

Better Outcomes and Incentives	4 Students with the most improved grades in the current STEM classes are given incentives.	4.38	.634	Very High
	2 Students find STEM careers to be emotionally rewarding.	4.19	.592	High
	1 The goals of the current STEM program are introduced early.	4.07	.597	High
	3 High performing students in science-based subjects are mostly attracted to the current STEM program.	3.86	.899	High
	Cluster 3 Total	4.12	.482	High
Attracting and Retaining the Best Minds	1 A STEM major will help me to fulfill the vision of the UAE becoming an innovation driven economy.	4.36	.560	Very High
	2 STEM skills will allow students to enter the major of their choice easily.	4.20	.627	Very High
	3 Students with STEM skills will have greater chances for their career choice.	4.18	.573	High
	Cluster 4 Total	4.25	.514	Very High
Future Vision	6 The current STEM program always offers internships.	3.86	.631	High
	5 The current STEM related program gives clear guidance on future careers	3.72	.684	High
	2 The current STEM program gives students regular opportunities to meet STEM role models.	3.52	.784	High
	7 Teachers are given the opportunity to effectively coordinate with universities to improve the current STEM program.	3.50	.793	High
	3 The current STEM program offers students volunteer projects to work on with other companies and organizations.	3.46	.803	High
	4 The current STEM program regularly organizes trips to companies involved in STEM.	3.46	.823	High
	1 The current STEM program closely communicates with universities to provide STEM workshops.	3.40	.840	High
	8 There is a regular collaboration between schools, universities and industry to improve the current STEM program.	3.27	.800	Medium

	Cluster 5 Total	3.53	.468	High
	Total of the three clusters	3.89	.653	High

Table 4.17 shows that the degree of governmental school leaders and teachers' perceptions towards better outcomes and incentives was reported very high in 1 item of this cluster and 3 items were high. The mean score of all items of this cluster ranged between 4.38 and 3.86. The total mean score was 4.12 of the cluster of *Better Outcomes and Incentives*. The table also shows that the degree of governmental school leaders' perceptions towards *Attracting and Retaining the Best Minds* was reported very high in 2 items of this cluster and 1 item was high. The mean score of all items of this cluster ranged between 4.36 and 4.18. The total mean score was 4.25 of the cluster of *Attracting and Retaining the Best Minds*. Additionally, it shows that the degree of governmental school leaders' perceptions towards *Future Vision* was reported high in 7 items of this cluster and 1 item was medium. The mean score of all items of this cluster ranged between 3.86 and 3.27. The total mean score was 3.53 of the cluster of Future vision. The total average mean score was reported 3.89.

Table 4.18: Descriptive Statistics of Governmental School Students' Perceptions towards STEM Careers and Career Interests (N =361)

	Variable	Mean	SD	Degree
Better Outcomes and Incentives (N =361)	16 Most STEM careers require hard work.	3.95	.953	High
	13 My current STEM subjects contain helpful information on STEM careers.	3.73	.947	High
	14 Most STEM careers are in high demand.	3.52	.983	High
	15 Most STEM careers have high paying jobs.	3.48	.937	High
	Cluster 3 Total	3.67	.709	High
Attracting and Retaining the Best Minds	20 It is important that awards are given to students with the most improved grades in my current STEM program.	4.06	1.03	High

	17 The goals of the STEM program I joined are clear.	3.68	1.039	High
	18 My current STEM program is emotionally rewarding.	3.66	1.013	High
	19 My achievements in my current STEM program are recognized by the community.	3.48	1.030	High
	Cluster 4 Total	3.72	.770	High
Future Vision	21 A STEM major will help me to fulfill the vision of the UAE becoming an innovation driven economy.	3.99	1.078	High
	22 Studying STEM will help me get into the major that I want easily.	3.70	1.091	High
	23 By studying STEM, I will be able to get the job I want easily.	3.56	1.063	High
	Cluster 5 Total	3.75	.880	High
		3.71	.658	High

Table 4.18 shows that the degree of governmental school students' perceptions towards *Better Outcomes and Incentives* was reported high in 4 items of this cluster. The mean score of all items of this cluster ranged between 3.95 and 3.48. The total mean score was 3.67 of the whole cluster.

Table 4.18 also shows that the degree of governmental school students' perceptions towards *Attracting and Retaining the Best Minds* was reported high in 4 items of this cluster. The mean score of all items of this cluster ranged between 4.06 and 3.48. The total mean score was 3.72 of the whole cluster. In addition, Table 4.18 shows that the degree of governmental school students' perceptions towards *Future Vision* was reported high in 3 items of this cluster. The mean score of all items of this cluster ranged between 3.99 and 3.56. The total mean score was 3.75 of the whole cluster.

Table 4.19: Descriptive Statistics of Governmental School Parents' Perceptions towards STEM Careers and Career Interests (N =101)

Variable	Mean	SD	Degree

Better Outcomes and Incentives	6- My (son/daughter) has the freedom of choice when choosing a career.	4.34	.682	Very High
	5- I will encourage my (son/daughter) to study STEM subjects in university.	3.91	.826	High
	4- Most STEM careers need hard work	3.88	.864	High
	1- The STEM subjects in my (son/daughters)'s current STEM program is linked to career choices.	3.80	.825	High
	2- There is a high demand for STEM careers.	3.66	.840	High
	3- Most STEM careers are well paid.	3.60	.813	High
	Cluster 2 Total	3.87	.558	High
Future Vision	1- A STEM major will help my (son/daughter) to fulfill the vision of the UAE becoming an innovation-driven society.	4.07	.875	High
	3- STEM skills will allow my (son/daughter) to get the job they want easily.	3.86	.980	High
	2- STEM skills will allow my (son/daughter) to enter the major of their choice easily.	3.82	1.033	High
	Cluster 3 Total	3.92	.852	High
	Total of the two clusters	3.89	.653	High

Table 4.19 shows that the degree of governmental school parents' perceptions towards *Better Outcomes and Incentives* was reported very high in 1 item of this cluster and high in 4 items. The mean score of all items of this cluster ranged between 4.34 and 3.60. The total mean score was 3.87 of the whole cluster.

Table 4.19 shows that the degree of governmental school students' parents' perceptions towards *Future Vision was* reported high in 3 items. The mean score of all items of this cluster ranged between 4.07 and 3.82. The total mean score was 3.92 of the whole cluster. The total average mean score of the two clusters was 3.89.

Table 4.20: Descriptive Statistics of University Leaders'/ Teachers' Perceptions towards STEM Careers and Career Interests (N =54)

Cluster	Variable	Mean	SD	Degree
Better Outcomes and Incentives	[3.2- STEM-related careers are in high demand.]	4.41	.659	Very High
	[3.1- The current STEM-related programs are linked to student career choices.]	4.06	.899	High
	[3.4- Student performances in school greatly reflect potential STEM career success.]	4.06	.712	High
	[3.3- Most STEM-related careers are well paid.]	3.85	.878	High
	Cluster 2	4.09	.539	High
Attracting and Retaining the Best Minds	[4.3- High performing students in science-based subjects are mostly attracted to the current STEM program.]	4.20	.786	Very High
	[4.1- The goals of the current STEM program are introduced early.]	3.93	.866	High
	[4.2- Students find the current STEM program to be emotionally rewarding.]	3.80	.786	High
	[4.4- Students with the most improved grades in the current STEM classes are given incentives.]	3.56	.945	High
	Cluster 3	3.87	.604	High
Future Vision	[5.1- A STEM major will most likely help students to fulfill the vision of the UAE becoming an innovation driven economy.]	4.37	.681	Very High
	[5.2- STEM skills will allow students to enter the major of their choice easily.]	4.33	.752	Very High
	[5.3- Students with STEM skills will have greater chances for their career choice.]	4.31	.668	Very High
	Cluster 4	4.34	.563	Very High
	Total	4.10	449	High

Table 4.20 shows that the degree of university leaders'/ teachers' perceptions towards *Better Outcomes and Incentives* was reported very high in 1 item of this cluster and

high in 3 items. The mean score of all items of this cluster ranged between 4.41 and 3.85. The total mean score was 4.09 of the whole cluster. Table 4.20 also shows that the degree of university leaders'/ teachers' perceptions towards *Attracting and Retaining the Best Minds* was reported very high in 1 item and high in 3 items of this cluster. The mean score of all items of this cluster ranged between 4.20 and 3.56. The total mean score was 3.87 of the whole cluster. In addition, Table 4.20 shows that the degree of university leaders'/ teachers' perceptions towards *Future Vision* was reported very high in all 3 items of this cluster. The mean score of all items of this cluster ranged between 4.37and 4.31. The total mean score was 4.34 of the whole cluster. The total average mean score of the three clusters was 4.10.

Table 4.21: Descriptive Statistics of University Students' Perceptions towards STEM Careers and Career Interests (N =110)

Cluster	Variable	Mean	SD	Degree
Better Outcomes and Incentives	[4.4- STEM-related careers require hard work.]	4.38	.742	Very High
	[4.2- STEM-related careers are in high demand.]	4.00	.909	High
	[4.3- STEM-related careers have high paying jobs.]	3.83	.887	High
	[4.1- My current STEM-related subjects contain helpful information on STEM careers.]	3.72	1.076	High
	Cluster 3	3.98	.626	High
Attracting and Retaining the Best Minds	[5.4- It is important that awards are given to students with the most improved grades in my current STEM program.]	4.04	1.075	High
	[5.1- The goals of my program (which is related to STEM) are clear.]	3.98	.824	High
	[5.2- My current program (which is related to STEM) is emotionally rewarding.]	3.63	1.108	High

	[5.3- My achievements in my current program (which is related to STEM) are recognized by the community.]	3.53	1.155	High
	Cluster 4	3.79	.84380	High
Future Vision	[6.1- A major (related to STEM) will help me to fulfill the vision of the UAE becoming an innovation driven economy.]	4.27	.898	Very High
	[6.2- Studying a STEM-related subject will help me get into the major that I want easily.]	4.21	.791	Very High
	[6.3- By studying a STEM-related subject, I will be able to get the job I want easily.]	3.95	1.087	High
	Cluster 5	4.15	.776	High
	Total	3.99	.613	High

Table 4.21 shows that the degree of university students' perceptions towards Better Outcomes and Incentives was reported very high in 1 item of this cluster and high in 3 items. The mean score of all items of this cluster ranged between 4.38 and 3.72. The total mean score was 3.98 of the whole cluster. Table 4.21 also shows that the degree of university students' perceptions towards *Attracting and Retaining the Best Minds* was reported high in all the 4 items of this cluster. The mean score of all items of this cluster ranged between 4.04 and 3.53. The total mean score was 3.79 of the whole cluster. In addition, Table 4.21 shows that the degree of university students' perceptions towards *Future Vision* was reported very high in 2 items and high in 1 item of this cluster. The mean score of all items of this cluster ranged between 4.27and 3.95. The total average mean score of the three clusters was 3.99.

Table 4.22: Descriptive Statistics of Industry Leaders'/ Teachers' Perceptions towards STEM Careers and Career Interests (N =53)

	Mean	SD	Degree

Better Outcomes and Incentives	[3.2- STEM-related careers are in high demand.]	4.40	.716	Very High
	[3.4- Student performances in school greatly reflect potential STEM-related career success.]	4.11	.824	High
	[3.1- The current STEM-related programs are linked to student career choices.]	4.09	1.21	High
	[3.3- Most STEM-related careers are well paid.]	3.79	.927	High
	Cluster 2 Total	4.10	.55	High
Attracting and Retaining the Best Minds	[4.2- Students find STEM careers to be emotionally rewarding.]	4.49	.608	Very High
	[4.1- The goals of the current STEM-related program(s) are introduced early.]	4.28	.717	Very High
	[4.4 Students in the current STEM-related classes are given incentives.]	4.25	.830	Very High
	[4.3- High performing students in science-based subjects are mostly attracted to the current STEM-related program(s).]	3.75	.979	High
	Cluster 3 Total	4.19	.520	High
Future Vision	[5.1- A STEM-related major will help students to fulfill the vision of the UAE becoming an innovation driven economy.]	4.34	.807	Very High
	[5.2- STEM-related skills will allow students to enter the major of their choice easily.]	4.19	.810	High
	[5.3- Students with STEM-related skills will have greater chances for their career choice.]	3.98	1.118	High
	Cluster 4 Total	4.17	.649	High
	Total	4.15	.370	High

Table 4.22 shows that the degree of industry leaders'/ teachers' perceptions towards Better Outcomes and Incentives was reported very high in 1 item of this cluster and 3 items were high. The mean score of all items of this cluster ranged between 4.40 and 3.79. The total mean score was 4.10 of the whole cluster.

Table 4.22 also shows that the degree of industry leaders'/ teachers' perceptions towards *Attracting and Retaining the Best Minds* was reported very high in 3 items of this cluster and 1 item was high. The mean score of all items of this cluster ranged between 4.49

and 3.75. The total mean score was 4.19 of the whole cluster. Additionally, Table 4.22 shows that the degree of industry leaders'/ teachers' perceptions towards *Attracting and Retaining the Best Minds* was reported very high in 1 item of this cluster and 2 items were high. The mean score of all items of this cluster ranged between 4.34 and 3.98. The total mean score was 4.17 of the whole cluster. The total mean score for all the clusters was reported 4.15.

Table 4.23: Descriptive Statistics of Industry Students' Perceptions towards STEM Careers and Career Interests (N =101)

	Variable	Mean	SD	Degree
Better Outcomes and Incentives	4- STEM-related careers require hard work.	4.33	.861	Very High
	2- STEM-related careers are in high demand.	3.92	1.102	High
	3- STEM-related careers have high paying jobs.	3.88	1.00	High
	1- My current STEM-related subjects contain helpful information on STEM careers.	3.87	.945	High
	Cluster 5 Total	4.00	.725	High
Attracting and Retaining the Best Minds	4- It is important that awards are given to students with the most improved grades in my current STEM program.	4.18	.899	High
	1- The goals of my program (which is related to STEM) are clear.	3.93	.875	High
	2- My current program (which is related to STEM) is emotionally rewarding.	3.81	1.046	High
	3- My achievements in my current program (which is related to STEM) are recognized by the community.	3.45	1.269	High
	Cluster 4 Total	3.84	.788	High
Future Vision	1- A major (related to STEM) will help me to fulfill the vision of the UAE becoming an innovation driven economy.	4.13	1.083	High
	2- Studying a STEM-related subject will help me get into the major that I want easily.	4.11	.969	High
	3- By studying a STEM-related subject, I will be able to get the job I want easily.	4.09	1.021	High
	Cluster 5 Total	4.11	.912	High

Total of the clusters	3.97	.570	High

Table 4.23 shows that the degree of industry students' perceptions towards *Better Outcomes and Incentives* was reported very high in 1 item and high in 3 items. The mean score of all items of this cluster ranged between 4.33 and 3.87. The total mean score was 4.00 of the whole cluster of better outcomes and incentives.

Table 4.23 also shows that the degree of industry students' perceptions towards *Attracting and Retaining the Best Minds* was reported high in 4 items. The mean score of all items of this cluster ranged between 4.18 and 3.45. The total mean score was 3.84 of the whole cluster. In addition, Table 4.23 shows that the degree of industry students' perceptions towards *Future Vision* was reported high in 3 items. The mean score of all items of this cluster ranged between 4.13 and 4.09. The total mean score was 4.11 of the whole cluster of *Future Vision*. The total mean score for all the clusters was reported 3.97.

4.2.5 Summary of the Participants' Perceptions towards Future STEM Careers

To sum up, the average degree of the stakeholders' perceptions towards the three clusters of STEM career perceptions and career interests (*Better Outcomes and Incentives, Attracting and Retaining the Best Minds and Future Vision*) were "High" in the three institutions: government schools, university and industry.

4.2.6 Comparison Summary of Participants' Perceptions towards Formal and Informal STEM Education Programs and Future STEM Careers

This section will display the participants' perceptions towards Formal and Informal STEM Education Programs and Future STEM Careers. Analysis of participant perceptions include between clusters.

4.2.6.1 Students' Perceptions towards Formal and Informal STEM Education Programs and Future STEM Careers according to Gender

The Independent Samples T-Tests about STEM Perceptions and Future STEM Career and Career Interests Perceptions is shown in Table 4.24.

Table 4.24: Independent Samples T-Test of Students' Gender about STEM Perceptions and Future STEM Career and Career Interests Perceptions

Stakeholder	Cluster	Gender	N	Mean	SD	t	df	Sig. (2-tailed)
Governmental School Students	STEM Perceptions	male	110	3.58	.694	-.701	361	.484
		female	251	3.64	.642			
	Future STEM Career Perceptions and Career Interests.	male	110	3.67	.673	-.827	361	.409
		female	251	3.73	.688			
University Students	STEM Perceptions	male	53	3.56	1.435	-2.075	110	.140
		female	57	3.54	.623			
	Future STEM Career Perceptions and Career Interests.	male	53	3.55	.553	-1.116	110	.267
		female	57	3.97	.651			
Industry Students	STEM Perceptions	male	40	3.75	.441	.405	102	.686
		female	61	3.63	.521			
		male	40	3.94	.210	-.084	102	.933

Future STEM Career Perceptions and Career Interests.	female	61	3.97	.688

The Independent Samples T-Test results showed that there were no statistically significant differences between male Governmental School Students (M =3.58, SD =. 694) and female Governmental School Students (M = 3.64, SD = .642) about STEM Programs Perceptions; t (361) = -.701, p =.484. Also, the Independent Samples T-Test results showed that there were no statistically significant differences between male Governmental School Students (M =3.67, SD =. 673) and female Governmental School Students (M = 3.73, SD = .688) about Future STEM Career Perceptions and Career Interests.; t (361) = -.827, p =.409.

For the university students, the Independent Samples T-Test results showed that there were no statistically significant differences between male university students (M =3.56, SD =1. 435) and female university students (M = 3.54, SD = .623) about STEM programs perceptions; t (110) = -2.075, p =.140 Also, the Independent samples T-Test results showed that there were no statistically significant differences between male university students (M =3.55, SD =. 553) and female university students (M = 3.97, SD = .651) about *Future STEM Career Perceptions* and *Career Interests*.; t (110) = -1.116, p =.267.

Regarding the Industrial institutions' students, the Independent Samples T-Test results showed that there were no statistically significant differences between male university Students (M =3.75, SD =. 441) and female university students (M = 3.63, SD = .521) about STEM Programs Perceptions; t (102) =.0405, p =.686. Also, the Independent Samples T-Test results showed that there were no statistically significant differences between male university Students (M =3.594, SD =. 210) and female university students (M

= 3.97, SD = .688) about *Future STEM Career Perceptions* and *Career Interests*; t (102) = -.84, p =.933.

4.2.6.2 Comparison of the Governmental School Participants' Perceptions towards the Formal STEM Education Program and Future STEM Careers

A one-way ANOVA test was carried out to compare the responses of governmental school leaders/teachers, students and parents (See Table 4.25).

Table 4.25: ANOVA Analysis of Governmental School Leaders/Teachers, Students and Parents and Categories of STEM Perceptions and Future STEM Careers and Career Interests Perceptions

Cluster	Groups	Sum of Squares	df	Mean Square	F	Sig.
STEM Perceptions	Between Groups	31.929	2	15.964	35.600	.000
	Within Groups	260.994	582	.448		
	Total	292.923	584			
Future STEM Career Perceptions and Career Interests	Between Groups	18.992	2	9.496	24.102	.000
	Within Groups	229.699	583	.394		
	Total	248.691	585			

First, there were significant differences between three stakeholders' categories (leaders/teachers, students and parents) about *STEM Perceptions* at P<.000 for conditions F (2, *582*) = 35.600. In regard to *Future STEM Career Perceptions and Career Interests*, there were significant differences between three stakeholders' categories (leaders/teachers, students and parents) at P<.000 for conditions F (2, *583*) = 24.101.

It is beneficial to conduct multiple comparisons post hoc Tukey tests since statistical significance between conditions have been found.

Table 4.26: Multiple Comparisons Analysis of Governmental School Leaders/Teachers, Students and Categories of STEM Perceptions and Future STEM Careers and Career Interests Perceptions

Dependent Variable	(I) 1	(J) 1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval L\B	U/B
STEM Perceptions	Leaders/ teachers	Students	.59014*	.06994	.000	.4222	.7581
		Parents	.43770*	.08968	.000	.2224	.6530
	Students	Leaders/ teachers	-.59014*	.06994	.000	-.7581	-.4222
		Parents	-.15245	.07511	.129	-.3328	.0279
	Parents	Leaders/ teachers	-.43770*	.08968	.000	-.6530	-.2224
		Students	.15245	.07511	.129	-.0279	.3328
Future STEM Career Perceptions and Career Interests	Leaders/ teachers	Students	.45268*	.06553	.000	.2953	.6100
		Parents	.28991*	.08406	.002	.0881	.4917
	Students	Leaders/ teachers	-.45268*	.06553	.000	-.6100	-.2953
		Parents	-.16277	.07039	.063	-.3318	.0062
	Parents	Leaders/ teachers	-.28991*	.08406	.002	-.4917	-.0881
		Students	.16277	.07039	.063	-.0062	.3318

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

As shown in Table 4.26, there were significant effects for the perceptions of governmental school leaders/teachers and students towards *STEM Programs Perceptions* at p <.00. Additionally, there were significant effects for the perceptions of governmental school leaders/teachers and parents towards *STEM Programs Perceptions* at p <.00. Also, there were no significant effects for the perceptions of governmental school students and parents towards *STEM Programs Perceptions* at .129.

In regard to their perceptions towards *Future STEM Career Perceptions* and *Career Interests* there were significant effects for the perceptions of governmental school leaders/teachers and students towards *Future STEM Career Perceptions and Career Interests* at p <.002. Additionally, there were significant effects for the perceptions of governmental school leaders/teachers and parents towards *Future STEM Career*

Perceptions and Career Interests at p <.00. Also, there were no significant effects for the perceptions of governmental school students and parents towards STEM programs Perceptions at .063.

4.2.6.3 Comparison of the University Participants' Perceptions towards STEM Education Programs and Future STEM Careers

As shown in Table 4.27, an Independent Samples T-Test results was conducted to compare the results of university leaders/teachers and students.

Table 4.27: Independent Sample T-Test of University Students and Leaders/Teachers and their STEM Perceptions and Future STEM Careers and Career Interests Perceptions

Cluster	Stakeholder	N	Mean	SD	df	t	Sig. (2-tailed)
STEM Perceptions	Students	110	4.32	.661	161	1.032	.303
	Leaders/ teachers	54	4.22	.521			
Future STEM Career Perceptions and Career Interests	Students	110	3.96	.652	161	-1.200	.232
	Leaders/ teachers	54	4.08	.452			

No statistically significant differences were found between university students (M = 4.32, SD =. 661) and university leaders/teachers (M = 4.22, SD = .521) about *STEM Programs Perceptions*; t (161) = 1.032, p =.303. In addition, there were no statistically significant differences between university students (M = 3.96, SD =. 652) and university leaders/teachers (M = 4.08, SD = .452) about *Future STEM Career Perceptions and Career Interests;* t (161) = -1.20, p =.303.

4.2.6.4 Comparison of the Industry Participants' Perceptions towards Informal STEM Education Programs and Future STEM Careers

As shown in Table 4.28, an Independent Samples T-Test results was conducted to compare the results of industry leaders/teachers and students.

Table 4.28: Independent Sample T-Test of Industry Students' and Leaders/ Teachers' STEM Perceptions and Future STEM Careers and Career Interests Perceptions

Cluster	Stakeholder	N	Mean	SD	F	t	df	Sig. (2-tailed)	Effect Size
STEM Perceptions	I/ L	53	4.14	.381	2.800	6.171	155	.000	1.1
	I/ Students	101	3.64	.514					
Future STEM Career Perceptions and Career Interests	I/L	53	4.12	.386	10.499	1.597	155	.112	-
	I/ Students	101	3.96	.670					

There were statistically significant differences between industry students (M = 4.14, SD =. 381) and industry leaders/teachers (M = 3.64, SD = .514) about *STEM Programs Perceptions*; t (155) = 6.171, p =.000. Effect size Cohen's d = 1.1 that indicates the significant differences was high between the perception of leaders and students. In addition, there were no statistically significant differences between industry students (M = 3.96, SD =. 386 and industry leaders/teachers (M = 4.12, SD = .670) about *Future STEM Career Perceptions and Career Interests*; t (155) = -1.597, p =.112.

4.2.6.5 Comparison of the Leaders' and Teachers' Perceptions towards STEM Education Programs and Future STEM Careers Between and Within Clusters

A one-way ANOVA was conducted to compare the perceptions of leaders/teachers in the three organizations (See Table 4.29).

Table 4.29: ANOVA Analysis of Leaders'/Teachers' STEM Perceptions and Future STEM Careers and Career Interests Perceptions

		Sum of Squares	df	Mean Square	F	Sig.
STEM Perceptions	Between Groups	.813	2	.406	1.176	.310
Future STEM Career Perceptions and Career Interests	Within Groups	97.816	283	.346		
	Total	98.629	285			
	Between Groups	2.414	2	1.207	4.211	.016
	Within Groups	81.123	283	.287		
	Total	83.537	285			

The ANOVA normality checks and Levene's test were carried out and the assumptions met. A one-way ANOVA test was carried out to compare the responses of Governmental School leaders/teachers, university leaders/teachers, and industry leaders/teachers of STEM Perceptions. First, there were no significant differences between three stakeholders' categories (Governmental School leaders/teachers, university leaders/teachers and industry leaders/teachers) about *STEM Perceptions* at P<.310 for conditions F (2, *283*) = 1.176. In regard to *Future STEM Career Perceptions* and *Career Interests*, there were significant differences between three stakeholders' categories (Governmental School leaders/teachers, university leaders/teachers and industry leaders/teachers) at P<.016 for conditions F (2, *283*) = 4.211.

It is beneficial to conduct multiple comparison post hoc Tukey tests since statistical significance between conditions have been found.

Table 4.30: Multiple Comparisons Analysis of Perceptions of Governmental School Leaders/ Teachers, University Leaders/ Teachers and Industry Leaders/ Teachers about STEM Perceptions and Future STEM Careers and Career Interests Perceptions

Multiple Comparisons

Tukey HSD

D/V	(I) VAR00001	(J) VAR00001	M/ D (I-J)	Std. Error	Sig.	95% Confidence Interval L/B	U/P
STEM Perceptions	Governmental School L-T	University L/T	-.11125	.07734	.323	-.2935	.0710
		Industry L-T	-.00506	.09597	.998	-.2312	.2211
	University L-T	Governmental School L-T	.11125	.07734	.323	-.0710	.2935
		Industry L-T	.10619	.09784	.524	-.1243	.3367
	Industry L-T	G- School L-T	.00506	.09597	.998	-.2211	.2312
		University L-T	-.10619	.09784	.524	-.3367	.1243
Future STEM Career Perceptions and Career Interests	Governmental School L-T	University L-T	.20419*	.07043	.011	.0383	.3701
		Industry L-T	.08557	.08740	.591	-.1204	.2915
	University L-T	G- School L-T	-.20419*	.07043	.011	-.3701	-.0383
		Industry L-T	-.11862	.08910	.379	-.3285	.0913
	Industry L-T	Governmental School L-T	-.08557	.08740	.591	-.2915	.1204
		University L-T	.11862	.08910	.379	-.0913	.3285

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

As shown in Table 4.30, there were no significant effects regarding governmental school leaders/teachers and university leaders/teachers towards *STEM programs Perceptions* at p <.323. Additionally, there were no significant effects for the perceptions of governmental school leaders/teachers and industry leaders towards *STEM Programs Perceptions* at p <.998. Also, there were no significant effects for the perceptions of university leaders/teachers and industry leaders towards *STEM Programs Perceptions* at .323.

Regarding their perceptions towards *Future STEM Career Perceptions and Career Interests*, there were significant differences of perceptions of governmental school leaders/teachers and university leaders/teachers towards *STEM Future Career Perceptions* and *Career Interests* at p <.011. However, there were no significant effects for the perceptions of governmental school leaders/teachers and industry leaders/teachers towards *STEM Programs Perceptions* at p <.591. Also, there were no significant differences for the perceptions of university leaders/teachers and industry leaders/teachers towards *STEM Programs Perceptions* at .379.

4.2.6.6 Comparison of the Students' Perceptions towards STEM Education Programs and Future STEM Careers Between and Within Clusters

A one-way ANOVA was conducted to compare the perceptions of leaders/teachers in the three organizations (See Table 4.31).

Table 4.31: ANOVA Analysis of Students' STEM Perceptions, Future STEM Career Perceptions and Career Interests

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
STEM Perceptions	Between Groups	42.925	2	21.462	53.310	.000
	Within Groups	229.881	571	.403		
	Total	272.806	573			
Future STEM Career Perceptions and Career Interests.	Between Groups	8.319	2	4.160	9.124	.000
	Within Groups	260.782	572	.456		
	Total	269.102	574			

Normality checks and Levene's test were carried out and the assumptions met. A one-way ANOVA test was carried out to compare the responses of Governmental School students, university students and industry students of *STEM Perceptions.* First, there were significant differences between three stakeholders' categories (Governmental School students, university students and industry students) about *STEM Perceptions* at P <.000 for conditions F (2, *572*) = 53.310. In regard to *Future STEM Career Perceptions and Career Interests*, there were significant differences between three stakeholders' categories (governmental school students, university students and industry students) at P<.000 for conditions; F (2, *572*) = 9.124.

Table 4.32: Multiple Comparisons Analysis of Students and their STEM Perceptions, Future STEM Career Perceptions and Career Interests.

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) VAR00001	(J) VAR00001	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval L/B	95% Confidence Interval U/B
STEM Perceptions	Governmental Schools L-T	University L-T	-.11125	.07734	.323	-.2935	.0710
		Industry L-T	-.00506	.09597	.998	-.2312	.2211
	University L-T	Governmental Schools L/T	.11125	.07734	.323	-.0710	.2935
		Industry L-T	.10619	.09784	.524	-.1243	.3367
	Industry L-T	Governmental Schools L-T	.00506	.09597	.998	-.2211	.2312
		University L-T	-.10619	.09784	.524	-.3367	.1243
Future STEM Career Perceptions and Career Interests.	Governmental Schools L-T	University L-T	.20419*	.07043	.011	.0383	.3701
		Industry L-T	.08557	.08740	.591	-.1204	.2915
	University L-T	Governmental Schools L-T	-.20419*	.07043	.011	-.3701	-.0383
		Industry L-T	-.11862	.08910	.379	-.3285	.0913
	Industry L-T	Governmental Schools L-T	-.08557	.08740	.591	-.2915	.1204
		University L-T	.11862	.08910	.379	-.0913	.3285

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

As shown in Table 4.32, there were significant differences of the perceptions of governmental school students and university students towards *STEM Programs Perceptions* at p <.000. However, there were no significant differences for the perceptions of governmental school students and industry students towards *STEM Programs Perceptions* at p <.984. Also, there were significant differences for the perceptions of university students and Industry leaders towards STEM Programs Perceptions at <.000.

Regarding their perceptions towards *Future STEM Career Perceptions and Career Interests*, there were significant differences of perceptions of governmental school students and university students towards *STEM Future Career perceptions and Career Interests* at p <.002. Also, there were significant differences for the perceptions of governmental school students and industry students towards *Future STEM Career Perceptions and Career Interests* at p <.003. Also, there were no significant differences for the perceptions of university students and industry students towards *Future STEM Career Perceptions and Career Interests* at <1.000.

4.2.7 Comparison Summary of the Participants' Perceptions towards STEM Education Programs and Future STEM Careers Between and Within Clusters

Table 4.49 summarizes the participants' perceptions between and within clusters. For governmental school stakeholders, there were statistically significant differences between the mean scores of perceptions of governmental school leaders/teachers, students and parents about *STEM Perceptions*, *Future STEM Career Perceptions and Career Interests* in favor of leaders/teachers. However, there were statistically significant differences between the mean scores of the perceptions of governmental school students and parents towards *STEM Programs Perceptions*, *Future STEM Career Perceptio*ns and *Career Interests*.

For industry stakeholders, there were statistically significant differences between industry students and industry leaders/teachers about *STEM Programs Perceptions* in favor of leaders. In addition, there were no statistically significant differences between industry students and industry leaders/teachers about *Future STEM Career Perceptions* and *Career Interests*.

Regarding university stakeholders, there were no statistically significant differences between the mean scores of perceptions of university leaders/teachers and students about STEM *Perceptions and Future STEM Career Perceptions and Career Interests*.

For leaders/teachers, there were no significant differences between three stakeholders' categories (governmental school leaders/teachers, university leaders/teachers, and industry leaders/teachers about *STEM Perceptions*. Regarding *Future STEM Career Perceptions* and *Career Interests*, there were significant differences between three stakeholders' categories (governmental school leaders/teachers, university leaders/teachers and industry leaders/teachers) in favor of industry leaders/teachers. Regarding their perceptions towards *Future STEM Career Perceptions and Career Interests*, there were significant differences of perceptions of governmental school leaders/teachers and university leaders/teachers towards *STEM Future Career Perceptions and Career Interests* in favor of university leaders/teachers. There were significant differences in perceptions of university leaders/teachers and industry leaders/teachers towards *STEM Future Career Perceptions and Career Interests* in favor of industry leaders/teachers.

For students, no gender significant differences were found between male and female students. Also, there were significant differences in the perceptions of governmental school students and university students towards *STEM Programs Perceptions* in favor of university students. However, there were no significant differences for the perceptions of governmental school Students and Industry students towards *STEM Programs Perceptions*. Also, there were significant differences for the perceptions of university students and industry leaders towards *STEM Programs Perceptions*. Regarding their perceptions towards *Future STEM Career Perceptions and Career Interests*, there were significant differences of perceptions of governmental school students and university students towards *STEM Future Career Perceptions and Career Interests* in favor of university students. Also, there were significant differences for the perceptions of governmental school students and industry students towards *Future STEM Career Perceptions and Career Interests* in favor of industry students. Also, there were no significant differences for the perceptions of university students and industry students towards *Future STEM Career Perceptions* and *Career Interests*.

This question tackles the perceptions of stakeholders; leaders/teachers, students and parents at governmental school, university and industry towards Triple Helix relationships with STEM programs and career choices in the UAE. Tables 4.33-4.39 will present descriptive statistics of perceptions of leaders/teachers, students and parents in the three clusters towards the Triple Helix Components (*Coordination and Communication among Universities, Industries and STEM Programs and STEM Strategy*). Then, comparisons (Tables 4.40-4.48) will be held with each institution (governmental schools, university and industry). Next, leaders and students will be compared in the three institutions.

4.2.8 Governmental Schools' Participants' Perceptions towards Triple Helix Components

Table 4.33 shows that the degree of governmental school leaders'/teachers' perceptions towards *Coordination and Communication among Universities, Industries and STEM programs.*

Table 4.33: Descriptive Statistics of Governmental School Leaders'/teachers' Perceptions towards Triple Helix Components *(Coordination and Communication among Universities, Industries and STEM Programs and STEM Strategy*) (N =123)

Cluster	Variable	Mean	SD	Degree
Coordination and	6 The current STEM program always offers internships.	3.86	.631	High
communicatio n among	5 The current STEM related program gives clear guidance on future careers	3.72	.684	High

universities, industries and STEM programs	2The current STEM program gives students regular opportunities to meet STEM role models.	3.52	.784	High
	7 Teachers are given the opportunity to effectively coordinate with universities to improve the current STEM program.	3.50	.793	High
	3 The current STEM program offers students volunteer projects to work on with other companies and organizations.	3.46	.803	High
	4 The current STEM program regularly organizes trips to companies involved in STEM.	3.46	.823	High
	1 The current STEM program closely communicates with universities to provide STEM workshops.	3.40	.840	High
	8 There is a regular collaboration between schools, universities and industry to improve the current STEM program.	3.27	.800	Medium
	Total of the cluster of Coordination and communication among universities, industries and STEM programs	3.53	.468	High
Perceptions on STEM Strategy	3 The current STEM program mainly focuses on 21st century skills.	4.29	.539	High
	1 The current STEM program encourages students to pursue STEM careers successfully.	4.07	.589	High
	4 Feedback from teachers is always taken into consideration when developing the STEM program.	4.02	.718	High
	2 The current STEM professional development is implemented effectively for teachers.	3.79	.842	High
	6 The current STEM program mostly meets the demands of industries.	3.83	.721	High
	5 Sufficient allocations are always made for STEM education resources into the STEM program.	3.59	.857	High
	Total of the cluster Perceptions on STEM Strategy	3.93	.480	High
	Total of the two clusters	3.73	.402	High

The degree of governmental school leaders'/teachers' perceptions towards *Coordination and Communication among Universities, Industries and STEM programs* was reported high in 7 items of this cluster and 1 item was medium. The mean scores of all items of this cluster ranged between 3.86 and 3.27. The total mean score was 3.53 of the total of the cluster of Coordination and communication among universities, industries and STEM programs. Additionally, it was shown that the degree of governmental school leaders'/teachers' *Perceptions towards STEM Strategy* was reported high in all 6 items of this cluster. The mean scores of all items of this cluster ranged between 4.29 and 3.59. The total mean score was this cluster was 3.93 and its degree level was High. The total average mean score of the Triple Helix Components was found 3.73 and the degree level average of the total was reported high.

Table 4.34: Descriptive Statistics of Governmental School Parents' Perceptions towards Triple Helix Components (*Coordination and Communication among Universities, Industries and STEM Programs*) (N =101)

Variable	Mean	SD	Degree
6- The current STEM program always offers internships.	3.83	.949	High
5- The current STEM program gives clear guidance on STEM future careers.	3.72	.950	High
1- Universities offer after-school STEM workshops regularly for my (son/daughter) in their current STEM program.	3.72	1.021	High
2- The current STEM program provides my (son/daughter) many opportunities to meet STEM role models.	3.57	1.023	High
3- The current STEM program offers many volunteer projects for my (son/daughter) to work on with other companies and institutions.	3.48	1.137	High
4- The current STEM program regularly organizes trips to companies involved in STEM.	3.39	1.122	High
Total of the Cluster Coordination and communication among universities, industries and STEM program	3.62	.87316	High

Table 4.34 shows that the degree of governmental school parents' *Perceptions towards Triple Helix Components* (*Coordination and Communication among Universities, Industries and STEM Programs*) was reported high in the 6 items of this cluster. The mean scores of all items of this cluster ranged between 3.83 and 3.39. The total mean score was 3.62 for the cluster of *Triple Helix Components* (*Coordination and communication among*

universities, industries and STEM Programs). The total mean score was 3.62 of the totals of the *Triple Helix Components* and the degree level average of the total was reported High.

Table 4.35: Descriptive Statistics of Governmental School Students' Perceptions towards Triple Helix Components (*Coordination and Communication among Universities, Industries and STEM Programs*) (N =361)

Variable	Mean	SD	Degree
24 After-school university workshops in my current STEM program are arranged regularly.	3.35	1.006	High
29 My current STEM program always offers internships.	3.27	.879	High
28 My current STEM program helps me to choose my future job.	3.17	.917	Medium
25 My current STEM program always gives me the chance to meet STEM role models (famous people).	3.16	.893	Medium
26 My current STEM program gives me the chance to volunteer with companies and institutions related to STEM.	3.16	.917	Medium
27 My current STEM program provides some trips to companies that are involved in STEM.	3.02	.896	Medium
Total of the Cluster Coordination and communication among universities, industries and STEM program	3.19	.637	Medium

Table 4.35 shows that the degree of governmental school students' *Perceptions towards Triple Helix Components* (*Coordination and Communication among Universities, Industries and STEM Programs*) was reported high in 2 items of this cluster and 4 items were medium. The mean scores of all items of this cluster ranged between 3.35 and 3.02. The total mean score was 3.19 for the cluster of Triple Helix Components (*Coordination and Communication among Universities, Industries and STEM Programs*). The total mean score was 3.19 for the Triple Helix Components and the degree level average of the total was reported medium.

4.2.9 University Participants' Perceptions towards Triple Helix Components

Table 4.36 shows that the degree of university leaders'/teachers' *Perceptions towards Coordination and Communication among Universities, Industries and STEM education Programs*.

Table 4.36: Descriptive Statistics of University Leaders' / Teachers' Perceptions towards Triple Helix Components (*Coordination and Communication among Universities, Industries and STEM Education Programs*) (N =54)

Cluster	Variable	Mean	SD	Degree
Coordination and Communication among Universities, Industries and STEM Programs	[6.1- The current STEM-related program closely communicates with other schools to provide STEM workshops.]	3.69	.773	High
	[6.2- The current STEM-related program gives students regular opportunities to meet STEM role models.]	3.74	.894	High
	[6.3- The current STEM-related program offers students projects to work on with other companies and organisations.]	3.61	.834	High
	[6.4- The current STEM-related program regularly organizes trips to companies involved in STEM.]	3.67	.869	High
	[6.5- The current STEM-related program gives clear guidance on future careers.]	3.74	.782	High
	[6.6- The current STEM-related program always offers internships.]	3.74	.873	High
	[6.7- The institution communicates regularly with universities to improve the current STEM-related program.]	3.65	.850	High
	[6.8- There is a regular collaboration between schools, universities and industry to improve the current STEM program.]	3.52	.771	High
	Total of the Cluster Coordination and communication among universities, industries and STEM program	3.67	.603	High
Perceptions on STEM Strategy	[7.1- The current STEM-related program encourages students to pursue STEM careers successfully.]	4.00	.824	High
	[7.2- STEM-related professional development for industry leaders is implemented effectively.]	3.83	.863	High

[7.3- The current STEM-related program mainly focuses on 21st century skills.]	3.89	.883	High
[7.4- Feedback from leaders is always taken into consideration when developing the current STEM-related program.]	3.91	.937	High
[7.5- Sufficient allocations are always made for STEM-related education resources into the current STEM-related program.]	3.72	1.017	High
[7.6- The current STEM-related program mostly meets the demands of industries.]	3.91	.917	High
Total of the Cluster of Perceptions on STEM Strategy	3.88	.736	High
Total	3.77	.628	High

The degree of university leaders'/teachers' *Perceptions towards Coordination and Communication among Universities, Industries and STEM Education Programs* was reported high in the 8 items of this cluster. The mean scores of all items of this cluster ranged between 3.69 and 3.52. The total mean score was 3.67 of the total of the cluster of Coordination and *Communication among Universities, Industries and STEM Programs*. Additionally, it shows that the degree of university leaders'/teachers' *Perceptions on STEM Strategy* was reported high in all 6 items of this cluster. The mean scores of all items of this cluster ranged between 4.00 and 3.91. The total mean score was 3.88 of this cluster. Also, the total of the Triple Helix Components of the two clusters was found 3.77and the degree level average of the total was reported high.

Table 4.37: Descriptive Statistics of University Students' Perceptions towards Triple Helix Components (*Coordination and Communication among Universities, Industries and STEM Programs*) (N =110)

Variable	Mean	SD	Degree
Coordination and communication of universities, industry and STEM program [7.5- My current program (related to STEM) helps me to choose my future job.]	3.59	1.214	High
Coordination and communication of universities, industry and STEM program [7.1- After-school university workshops (related to STEM) in my current program are arranged regularly.]	3.46	1.194	High

Coordination and communication of universities, industry and STEM program [7.6- My current program (related to STEM) always offers internships.]	3.37	1.291	Medium
Coordination and communication of universities, industry and STEM program [7.2- My current program (related to STEM) always gives me the chance to meet STEM role models (famous people).]	3.29	1.330	Medium
Coordination and communication of universities, industry and STEM program [7.3- My current program (related to STEM) gives me the chance to volunteer with companies and institutions related to STEM.]	3.25	1.391	Medium
Coordination and communication of universities, industry and STEM program [7.4- My current program (related to STEM) provides some trips to companies that are involved in STEM.]	3.19	1.378	Medium
Total of the Cluster Coordination and communication among universities, industries and STEM program	3.36	1.12757	Medium

Table 4.37 shows that the degree of university students' *Perceptions towards Triple Helix Components (Coordination and Communication among Universities, Industries and STEM Programs)* was reported high in 2 items of this cluster and 4 items were medium. The mean scores of all items of this cluster ranged between 3.59 and 3.19. The total mean score average was 3.36 for the cluster of *Triple Helix Components* (*Coordination and Communication among Universities, Industries and STEM Programs*) and the degree level average of the total was reported medium.

4.2.10 Industry Participants' Perceptions towards Triple Helix Components

Table 4.38 shows that the degree of industry leaders' *Perceptions towards Coordination and Communication among Universities, Industries and STEM Programs.*

Table 4.38: Descriptive Statistics of Industry Leaders' Perceptions towards Triple Helix Components (*Coordination and Communication among Universities, Industries and STEM Programs*) (N =53)

Cluster	Variable	Mean	SD	Degree
Coordination and communication among universities, industries and STEM programs	5- The current STEM-related program gives clear guidance on future careers.]	3.79	1.133	High
	1- The current STEM-related program closely communicates with other schools to provide STEM workshops.]	3.66	1.270	High
	.4- The current STEM-related program regularly organizes trips to companies involved in STEM.]	3.60	1.321	High

	3- The current STEM-related program offers students projects to work on with other companies and organizations.]	3.57	1.201	High
	6- The current STEM-related program always offers internships.]	3.51	1.250	High
	8- There is a regular collaboration between schools, universities, and industry to improve the current STEM-related program.]	3.49	1.234	High
	7- The institution communicates regularly with universities to improve the current STEM-related program.]	3.34	1.091	Medium
	2- The current STEM-related program gives students regular opportunities to meet STEM role models.]	3.34	1.055	Medium
	Total of the cluster of Coordination and communication among universities, industries and STEM programs	3.54	.817	High
Perceptions on STEM Strategy	5- Sufficient allocations are always made for STEM-related education resources into the current STEM-related program.]	4.00	.855	High
	1- The current STEM-related program encourages students to pursue STEM careers successfully.]	3.85	1.045	High
	6- The current STEM-related program mostly meets the demands of industries.]	3.83	.778	High
	3- The current STEM-related program mainly focuses on 21st century skills.]	3.75	.959	High
	2- STEM-related professional development for industry leaders is implemented effectively.]	3.57	.888	High
	4- Feedback from leaders is always taken into consideration when developing the current STEM-related program.]	3.55	.992	High
	Total of the cluster of Perceptions on STEM Strategy	3.76	.664	High
	Total	3.65	.647	High

The degree of industry leaders' *Perceptions towards Coordination and Communication among Universities, Industries and STEM Programs* was reported high in the 8 items and medium in 2 items of this cluster. The mean scores of all items of this cluster ranged between 3.79 and 3.34. The total mean score was 3.54 for the cluster of *Coordination and Communication among Universities, Industries and STEM Programs*. Additionally, it shows that the degree of industry leaders' *Perceptions on STEM Strategy* was reported high in all 6 items of this cluster. The mean scores of all items of this cluster ranged between 4.00 and 3.55. The total mean score was 3.76 of this cluster. Also, the total of the *Triple*

Helix Components of the two clusters was found 3.65 and the degree level average of the total was reported High.

Table 4.39: Descriptive Statistics of Industry Students' Perceptions towards Triple Helix Components (*Coordination and Communication among Universities, Industries and STEM Programs*) (N =101)

Variable	Mean	SD	Degree
5- My current program (related to STEM) helps me to choose my future job.]	3.37	1.214	Medium
6- My current program (related to STEM) always offers internships.]	3.21	1.344	Medium
3- My current program (related to STEM) gives me the chance to volunteer with companies and institutions related to STEM.]	3.18	1.330	Medium
4- My current program (related to STEM) provides some trips to companies that are involved in STEM.]	3.13	1.324	Medium
1- After-school university workshops (related to STEM) in my current program are arranged regularly.]	3.07	1.290	Medium
2- My current program (related to STEM) always gives me the chance to meet STEM role models (famous people).]	2.86	1.435	Medium
Total of the cluster of Coordination and communication among universities, industries and STEM programs	3.14	1.100	Medium

Table 4.39 shows that the degree of industry students' *Perceptions towards Triple Helix Components* (*Coordination and Communication among Universities, Industries and STEM Programs*) was reported medium in the 6 items. The mean scores of all items of this cluster ranged between 3.37 and 2.86. The total mean score average was 3.14 of the total of the cluster of *Triple Helix Components* (*Coordination and Communication among Universities, Industries and STEM Programs*) and the degree level average of the total was reported Medium.

4.2.11 Summary of Participants' Perceptions towards Triple Helix Components

The degree of governmental school leaders'/teachers' and parents' *Perceptions towards Coordination and Communication among Universities, Industries and STEM programs* was reported high, but it was medium with school students. Similarly, the degree of university leaders'/teachers' perceptions towards *Coordination and Communication among Universities, Industries and STEM Programs* was reported high, but it was medium with university students. For industry, the industry leaders' *Perceptions towards Coordination and Communication among Universities, Industries and STEM programs* was reported high, but it was medium with industry students.

4.2.12 Students' Perceptions towards the Triple Helix Components According to Gender

As shown in Table 4.40, an Independent Samples T-Test results was conducted to compare the effects of gender of students towards their perceptions of the *Triple Helix Components*.

Table 4.40: Independent Samples T-Test of Students' Gender about Triple Helix Components

Stakeholder	Cluster	Gender	N	Mean	SD	t	df	Sig. (2-tailed)
Governmental School Students	Triple Helix component	male female	110 251	3.28 3.16	.610 .648	1.686	361	.093
University Students	Triple Helix component	male female	53 57	2.72 3.38	1.337 1.123	-.994	110	.322
Industry Students	Triple Helix component	male female	40 61	2.72 3.15	1.084 1.103	-.659	101	.512

The *Independent Samples T-Test results* showed that there were no statistically significant differences between male governmental school students (M =3.28, SD =. 610) and female governmental School Students (M = 3.16, SD = .648) about Triple Helix Components; t (361) = 1.686, p =.093.

For the university students, the *Independent Samples T-Test results* showed that there were no statistically significant differences between male university students (M =2.72, SD =1. 337) and female university Students (M = 3.38, SD = 1.123) about the Triple

Helix Components; t (110) = -.994, p =.322 Also, the Independent Samples T-Test results showed that there were no statistically significant differences between male industry Students (M =2.72, SD = 1. 084) and female industry Students (M = 3.15, SD = 1.103) about Triple Helix Components; t (101) = -.659, p =.512.

4.2.13 Comparison of the Participants' Perceptions towards Triple Helix Components

The following section displays the stakeholder results regarding the Triple Helix Components.

4.2.13.1 Comparison of Governmental School Leaders'/Teachers', Students' and Parents' Perceptions towards Triple Helix Components Between and Within Clusters

As shown in Table 4.41, an ANOVA analysis was conducted to compare the perceptions of stakeholders in the governmental school cluster regarding the *Triple Helix Components*.

Table 4.41: ANOVA Analysis of Governmental School Leaders, Students and Parents about Triple Helix Components

Cluster	Groups	Sum of Squares	df	Mean Square	F	Sig.
Triple Helix Components	Between Groups	31.535	2	15.768	37.894	.000
	Within Groups	242.584	583	.416		
	Total	274.119	585			

Regarding the *Triple Helix Components*, there were significant differences between three stakeholders' categories (governmental school leaders, students and parents) at P<.000 for conditions F (2, *283*) = 37.894.

Table 4.42: Multiple Comparisons Analysis of Governmental School Leaders, Students, Parents and Categories of STEM Perceptions, Future STEM Career Perceptions and Career Interests and Triple Helix Components

Dependent Variable	(I) 1	(J) 1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval L/B	U/B
Triple Helix Components	Governmental School Leaders/teachers	Students	.51358*	.06735	.000	.3519	.6753
		Parents	.08796	.08638	.027	-.1194	.2954
	Governmental School Students	Leaders/ teachers	-.51358*	.06735	.000	-.6753	-.3519
		Parents	-.42563*	.07233	.000	-.5993	-.2520
	Governmental School Parents	Leaders/ teachers	-.08796	.08638	.027	-.2954	.1194
		Students	.42563*	.07233	.000	.2520	.5993

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

As shown in Table 4.42, there were significant differences for the perceptions of governmental school leaders/teachers and students towards *Triple Helix Components* at p <.00. However, there were significant differences for the perceptions of governmental school leaders/teachers and parents towards *Triple Helix Components* at p <.027. Also, there were significant differences for the perceptions of governmental school students and parents towards *Triple Helix Components* at p <.027.

4.2.13.2 Comparison of the University Leaders'/ Teachers' and Students' Perceptions towards Triple Helix Components

An Independent Samples T-Test results was conducted to compare the University Students and Leaders' perceptions about *Triple Helix Components* (See Table 4.43).

Table 4.43: Independent Sample T-Test of University Students' and Leaders' Perceptions about Triple Helix Components

Cluster	Stakeholder	N	Mean	SD	F	t	df	Sig. (2-tailed)

Triple Helix Components.	University Students	110	3.37	1.13	26.359	-2.381	161	.018
	University Leaders/ teachers	54	3.76	.52				

The Independent Samples T-Test results showed that there were statistically significant differences between university students' perceptions (M =3.37, SD = 1.13) and university leaders/teachers (M = 3.76, SD = .52) about *Triple Helix Components*; t (161) = -2.381, p <.018 in favor of university leaders/teachers.

4.2.13.3 Comparison of the Industry Leaders' and Students' Perceptions towards Triple Helix Components

As shown in Table 4.44, an Independent Samples T-Test results was conducted to compare industry students and leaders' perceptions about *Triple Helix Components*.

Table 4.44: Independent Sample T-Test of Industry Students' and Leaders' perceptions about Triple Helix Components

Cluster	Stakeholder	N	Mean	SD	F	t	df	Sig. (2-tailed)
Triple Helix Components	Industry Leaders	53	3.32	.628	22.259	1.321	155	.188
	Industry Students	101	3.10	1.102				

The Independent Samples T-Test results showed that there were no statistically significant differences between industry students' perceptions (M =3.32, SD =.628) and industry leaders/teachers (M = 3.10, SD = 1.102) about *Triple Helix Components*; t (155) = 1.321, p <.188.

Table 4.45: ANOVA Analysis of Governmental School Leaders'/Teachers', University Leaders'/Teachers' and Industry Leaders'/Teachers' Perceptions about Triple Helix Components

		Sum of Squares	df	Mean Square	F	Sig.
Triple Helix Components	Between Groups	8.724	2	4.362	6.927	.001
	Within Groups	178.206	283	.630		
	Total	186.930	285			

Regarding the *Triple Helix Components*, there were significant differences between three stakeholders' categories (governmental school leaders/teachers, university leaders/teachers and industry leaders) at $p<.001$ for conditions $F(2, 283) = 6.927$.

Table 4.46: Multiple Comparisons Analysis of Perceptions of Governmental School Leaders/Teachers, University Leaders/Teachers and Industry Leaders/Teachers about Triple Helix Components

Tukey HSD

Dependent Variable	(I) VAR00001	(J) VAR00001	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval L/B	U/B
Triple Helix Components	Governmental School Leaders/ Teachers	University Leaders/ Teachers	.34194*	.10439	.003	.0960	.5879
		Industry Leaders	-.05126	.12954	.917	-.3565	.2540
	University Leaders/ teachers	Governmental School Leaders/ Teachers	-.34194*	.10439	.003	-.5879	-.0960
		Industry Leaders	-.39320*	.13205	.009	-.7043	-.0821
	Industry Leaders	Governmental School Leaders/ Teachers	.05126	.12954	.917	-.2540	.3565
		University Leaders/ Teachers	.39320*	.13205	.009	.0821	.7043

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

For the *Triple Helix Components* in Table 4.46, there were significant differences in perceptions of governmental school leaders/teachers and university leaders/teachers towards the *Triple Helix Components* at p <.003. However, there were no significant effects for the perceptions of governmental school leaders/teachers and industry leaders towards the *Triple Helix Components* at p <.917. Also, there were significant differences for the perceptions of university leaders/teachers and industry leaders/teachers towards the *Triple Helix Components* at <. 009.

Table 4.47: ANOVA Analysis of Students' Perceptions about Triple Helix Components among Government, University and Industry

		ANOVA Sum of Squares	df	Mean Square	F	Sig.
Triple Helix component	Within Groups	260.782	572	.456		
	Total	269.102	574			
	Between Groups	3.940	2	1.970	2.740	.065
	Within Groups	411.251	572	.719		
	Total	415.191	574			

Regarding the *Triple Helix Components* in Table 4.47, there were no significant differences between three stakeholders' categories (governmental school students, university students, and industry students) about the *Triple Helix Components* at P<.065 for conditions; F (2, 572) = 2.740.

It is beneficial to conduct multiple comparison post hoc Tukey tests since statistical significance between conditions have been found.

Table 4.48: Multiple Comparisons Analysis of Students' Perceptions about Triple Helix Components among Government, University and Industry

Multiple Comparisons

Dependent Variable	(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval L/B	95% Confidence Interval U/B
Triple Helix Components	Governmental	University Students	-.17165	.11345	.346	-.4460	.1027

School Students	Industry Students	.09120	.11268	.803	-.1814	.3638
University Students	Governmental School Students	.17165	.11345	.346	-.1027	.4460
	Industry Students	.26285	.15268	.237	-.1045	.6302
Industry Students	Governmental School Students	-.09120	.11268	.803	-.3638	.1814
	University Students	-.26285	.15268	.237	-.6302	.1045

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

For the student perceptions regarding *Triple Helix Components* among the three clusters (government, university and industry), there were no significant differences at p <.05 (Table 4.48).

4.2.14 Comparison Summary of the Participants' Perceptions towards Triple Helix Components

For governmental school stakeholders, there were statistically significant differences between the mean scores of perceptions of governmental school leaders/teachers and parents about *Triple Helix Components* in favor of leaders and teachers. In addition, there were statistically significant differences between the mean scores of the perceptions of governmental school students and parents towards the *Triple Helix Components* in favor of parents. Also, there were statistically significant differences between the mean scores of perceptions of governmental school leaders/teachers and students about *Triple Helix Components* in favor of leaders and teachers.

Regarding university stakeholders, there were statistically significant differences between the mean scores of perceptions of university leaders/teachers and students about *Triple Helix Components* in favor of leaders and teachers. For industry stakeholders, there were no statistically significant differences between industry students and industry leaders about *Triple Helix Components* in favor of leaders and teachers

For leaders, there were significant differences of perceptions of governmental school leaders/teachers and university leaders towards the *Triple Helix Components* in favor of university leaders. Also, there were significant differences for the perceptions of university leaders/teachers and industry leaders towards the *Triple Helix Components* in favor of university leaders. However, there were no significant effects for the perceptions of governmental school leaders/teachers and industry leaders towards the *Triple Helix Components*.

For students, no gender significant differences were found between male and female students. Also, there were no significant differences in the perceptions of governmental school students. University Students and industry students towards the Triple Helix component.

4.2.15 Summary of Results for Research Question 2

The following section includes the results for the second research question taken from the Likert-scale questions from the questionnaire.

For the quantitative results of Research Question 2, the average degree of the stakeholders' perceptions towards the three clusters of *STEM Career Perceptions and Career Interests, Better outcomes and Incentives, Attracting and Retaining the Best Minds and Future Vision* were "High" in the three institutions: government schools, university and industry.

For governmental school stakeholders, there were statistically significant differences between the mean scores of perceptions of governmental school leaders/teachers, students and parents about STEM perceptions and future STEM career perceptions and career interests in favor of leaders and teachers. However, there were statistically significant differences between the mean scores of the perceptions of governmental school students and parents towards STEM programs perceptions and future STEM career perceptions and career interests.

For industry stakeholders, there were statistically significant differences between industry students and industry leaders about STEM programs perceptions in favor of leaders. In addition, there were no statistically significant differences between industry students and industry leaders about future STEM career perceptions and career interests.

Regarding university stakeholders, there were no statistically significant differences between the mean scores of perceptions of university leaders/teachers, and students about STEM perceptions and future STEM career perceptions and career interests.

For leaders, there were no significant differences between three stakeholders' categories (governmental school leaders/teachers, university leaders/teachers and industry leaders) about STEM perceptions. In regard to future STEM career perceptions and career interests, there were significant differences between three stakeholders' categories (governmental school leaders/teachers, university leaders/teachers and industry leaders in favor of industry leaders. In regard to their perceptions towards *Future STEM Career Perceptions and Career Interests*, there were significant differences of perceptions of governmental school leaders/teachers and university leaders/teachers towards STEM future career perceptions and career interests in favor of university leaders/teachers. there were significant differences in perceptions of university leaders/teachers and industry leaders towards STEM future career perceptions and career interests in favor of industry leaders.

For students, no gender significant differences were found between male and female students. Also, there were significant differences in the perceptions of governmental school students and university students towards STEM programs perceptions in favor of university students. However, there were no significant differences for the perceptions of governmental school students and industry students towards STEM programs perceptions. Also, there were significant differences for the perceptions of university students and industry leaders towards *STEM Programs Perceptions*. In regard to their perceptions towards Future STEM Careers and Career Interests, there were significant differences of perceptions of governmental school students and university students towards STEM Future Career Perceptions and Career Interests in favor of university students. Also, there were significant differences for the perceptions of governmental school students and industry students towards *Future STEM Career Perceptions and Career Interests* in favor of industry students. Also, there were no significant differences for the perceptions of university students and industry students towards *Future STEM Career Perceptions and Career Interests.*

Table 4.49 summarizes the stakeholders' perceptions within and between clusters. For perceptions within clusters, all stakeholders from the three clusters ranked high or very high in the two categories, STEM educational programs and Future STEM careers, indicating their agreement. Although the students from all three clusters ranked medium in the Triple Helix category, this also means a positive perception. As a result, all stakeholders from the three clusters perceived all three categories positively. For inferential analysis, ANOVA was used to analyze the perceptions within clusters. For example, there are significant differences between leaders/teachers and students in the government and industry clusters. There are also non-significant differences between leaders/teachers and students in the industry and university clusters, which need further investigation.

For perceptions between clusters, student perceptions showed that there were significant differences in the STEM Educational program category between students from the government and university and students from the university and industry. There were non-significant differences between the leaders/teachers from all three clusters. In the

Future STEM Careers category, there were significant differences between leaders/teachers from the government and industry clusters. There were also significant differences between students from the government and university, and students from the government and industry. For the Triple Helix category, there were significant differences between the leaders/teachers from the government and university, and leaders/teachers from university and industry. There were no significant differences between the students.

Also, there were significant differences for the perceptions of university students and industry leaders towards *STEM Programs Perceptions*. In regard to their perceptions towards Future STEM Careers and Career Interests, there were significant differences of perceptions of governmental school students and university students towards STEM Future Career Perceptions and Career Interests in favor of university students. Also, there were significant differences for the perceptions of governmental school students and industry students towards *Future STEM Career Perceptions and Career Interests* in favor of industry students. Also, there were no significant differences for the perceptions of university students and industry students towards *Future STEM Career Perceptions and Career Interests.*

Table 4.49: Summary of the Perceptions of all Stakeholders within Clusters: and between Clusters

Perceptions Within Clusters	Perceptions Between Clusters
STEM Educational Programs *Government* L/T: High S: High P: High **Significant** • L/T-- P • L/T--S **Non - significant** • S--P *University* L/T: V. High S: V. High & High **Non - significant** • L/T--S *Industry*	**STEM Educational Programs** *Leaders'/Teachers' Perceptions* **Non - significant** • Government and University • Government and Industry • University and Industry Leaders/Teachers *Students' Perceptions*

L/T: V. High S: V. High & High **Significant** • L/T--S	**Significant** • Government and University • University and Industry **Non - significant** • Government and Industry
Future STEM Careers *Government* L/T: High S: V. High & High P: High **Significant** • L/T-- P • L/T--S **Non - significant** • S--P *University* L/T: V. High & High S: V. High & High **Non - significant** • L/T--S *Industry* L/T: V. High S: V. High & High **Non - significant** • L/T--S	**Future STEM Careers** *Leaders'/ Teachers' Perceptions* **Significant** • Government and University **Non - significant** • Government and Industry • University and Industry *Students' Perceptions* **Significant** • Government and University • Government and Industry **Non - significant** • University and Industry
Triple Helix *Government* L/T: High S: Med P: High **Significant** • L/T-- P • L/T--S • S--P *University* L/T: High S: Med **Significant** • L/T--S *Industry* L/T: High S: Med **Non - significant** • L/T--S	**Triple Helix** *Leaders'/ Teachers' Perceptions* **Significant** • Government and University • University and Industry **Non - significant** • Government and Industry *Students' Perceptions* **Non - significant** • Government and University • Government and Industry • University and Industry

4.3 Qualitative Data Analysis Results of the Semi-Structured Interviews

This section presents the second part of the explanatory sequential mixed method design which collected qualitative data. This section covers the results of the semi-structured interviews. The required information was collected from the UAE government schools and

15 participants have been selected among them that are known to be the leaders and the 7 participants of the industry serving from many years and they have been through much training and also 7 participants from the university including the professors. The results of these interviews can provide information about the stakeholders' beliefs regarding the collaboration with the Triple Helix model can benefit STEM education and STEM careers.

Interviewing teachers and leaders is important because they play a big role in ensuring that the STEM program is successful. It was necessary to check the perceptions of the teachers and leaders in each of the Triple Helix component through interviews. Furthermore, the results from the interviews can answer any lingering questions left from the open-ended questionnaire's results (Almalki 2016). The researcher followed the educational research guidelines outlined by Hunter (2012) for interview protocol. It started with the explanations about the reasons and the central goals of the investigation, then concluded with the qualitative questions. The questions started from a general level of questions to the more precise and detailed debatable questions that should be gathered.

Four open-ended questions were discussed with the teachers and leaders from each cluster during the interviews. During the interview, the researcher took notes and then later classified them into themes by coding them. The same procedure was used when analyzing the documents for the first research question. The table 4.50 below shows the list of the participants from each category and their relevant experience.

Table 4.50: The Number of Participants for Each Cluster

No	Participant's Institute (Triple Helix Cluster)	Number of Interview Participants
1	Government School	15
2	Industry	7
3	University	7

The interviews were conducted, and the collected data was analyzed and the questions were answered with the thorough examples. The next sections demonstrate each cluster participants' beliefs about each interview question.

4.3.1 Interview Question 1

Q1. Why do you think STEM (science, technology, education and math) education to benefit the UAE is preparing students for future industry needs and future vision 2030?

Government Teacher's/Leader's Responses:

All participants in the government schools agreed that the program builds the students' 21 century skills. A government school leader highlighted how future skills can contribute to innovation and said:

> "The program relies on integration and merging of students' skills to realistically apply scientific knowledge and enhance entrepreneurial skills as a concept, thought, practice and application within a framework of creativity and innovation to build generations and leaders of 21 century entrepreneurship skills and thinking process."

Additionally, a teacher emphasized how the 21st century skills being taught in STEM equips students for future career fields and said, "STEM-based learning gives students tools and methods to explore new and creative ways of problem-solving, displaying data, innovating and linking multiple fields."

Lastly, independent thinking was a result of 21st century skills being taught in STEM would help students remain competitive in a globalized job market as one of the leaders in the governments school said, "In STEM we need to make the students capable to think in a proper way to build his personality and skills for the future to plan and have a voice and defend his thoughts."

The second theme that was taken from the government teachers'/leaders' beliefs is the importance of including hands-on experience and real-life situations in STEM education. One teacher observed the importance of making learning relevant to the students' future careers and said:

> "The students enjoy the lessons that connect the subject with real life situations. For example, studying math is more interesting for them because it makes it more relevant to their lives. It also helps them to understand the importance of math in future careers like statistics. Apprenticeships can provide students with these experiences."

Another teacher commented on the positive learning impact of hands-on learning because it increases student engagement by saying, "It is an interesting way to teach the students because they enjoy it and it fits the students' style of learning. It has benefits for all, even the low achievers." Also, using a problem-based approach in STEM uses real-world issues encourages students to develop hands-on solutions. A teacher pointed out that, "The students know how to solve problems and are making surveys regarding what is needed in the society."

The third theme that emerged from the government teachers'/leaders' beliefs is the use of technology in STEM education. A teacher mentioned the importance of building students' technological skills: "The world has become increasingly dependent on technology. STEM encourages students to use technology and to innovate and find solutions to our problems."

Learning to use technology can also help students to adapt to future industry with research-based needs. A teacher said, "It prepares the students for more challenging situations and readiness in understanding the technology-based learning of other subjects. Students will be ready for the future with research skills." Another teacher remarked, "More practice with technology will increase the students' confidence."

Many of the participants' responses related to the fourth theme which is STEM curriculum. One teacher mentioned the importance of rewarding student efforts by providing certificates that prove that the students "spend certain hours to finish a project and can be calculated with their behaviour marks." Another teacher observed the obstacles in implementing the STEM curriculum and mentioned that "our lessons are too long and too complex to include STEM. We need support for the student's projects and innovations." In order to make the STEM curriculum more manageable, a teacher mentioned how the STEM curriculum should be balanced and have a clear end-goal in mind so that the lessons allow "students finish projects at the end of the semester." To support the projects included in the STEM curriculum, a teacher stated that "the initiative always comes from schools" and more support is needed from outsiders.

Industry Leaders'/Teachers' Responses:

The interview participants from the industry cluster agreed on the following three themes for the first interview question: increasing the students' skill set, organizing the material and tools and hands-on experience.

The first theme was increasing the students' skill set. One industry teacher commented on how the intersection between the four subjects and the interdisciplinary projects completed by the students improve their chances in competing in the future workforce since STEM "improves the student's skills which concentrate on the 21 century skills and their personality skills." One industry leader agreed and mentioned that STEM will build the practical skills that students need for the future in careers related to math and physics. Another participant emphasized that the new skills need to be updated so that students are ready for the future workforce. Such skills should also be multidisciplinary so that they are relevant for the future.

The second theme that participants agreed on was the need to organize the STEM curriculum material and resources. An industry teacher explained:

> "We work together to collaborate to rewrite curriculum so that it is aligned to current events as well as, the Summer and winter camps are also provided to supplement student learning by focusing sessions on key STEM terminology."

Another industry participant agreed and highlighted the need to include "more business-related assignments" because these "realistic classes" will help to align the STEM curriculum to future industry needs. Students might also need more structured support as one participant stated "the students benefited from an innovation lab that gave them direction and advice to finish their projects." Another participant also pointed out that the STEM curriculum should "include topics related to space and technology" and "incorporate artificial intelligence (AI), emerging fields in technology (such as robotics, coding and AI). This requires more updated technology to be incorporated into the STEM curriculum." It was also mentioned that "students need more STEM learning support during school hours and STEM learning also needs to happen outside of normal school hours." Another participant suggested that, "With technology, we can provide our students with innovative ways of learning. Technology can also help us to provide students with STEM online classes and extracurricular STEM activities."

Many of the participants also highlighted the third theme which is hands-on experience. An industry leader listed that the students participated in workshops that gave them experience with: "3D printing, electrical circles, laser machines and robotics." Another leader specified "the institution provided instructions with training on programming to help employees to achieve their goals. Project assistance is also provided to the students in universities and was also given to students.

University Leaders'/Teachers' Responses:

Regarding the first question, the university leaders and teachers agreed on two themes: increasing student skill set and hands-on experience.

One professor commented on the link between the UAE's goals and STEM education: "The UAE is preparing its citizens to contribute to the economy with their knowledge and skills in the STEM fields". Another professor also mentioned "skills gained from STEM education focuses on 21 century skills that enable students to possess professional skills that will serve them for the future." Additionally, a university participant stated that "support for students' future STEM careers should include participation in STEM conferences." The skills that the students learn should address the gap in the future STEM workforce in "fields such as micro fabrication, robotics, artificial intelligence and biomedicine." Additionally, "more emphasis on the artificial intelligence methods" was identified by a participant.

To gain relevant experience, the participants from the university cluster agreed on the second theme which is the importance of students gaining hands-on experience. One university professor highlighted "hands-on lessons increase student engagement, the students enjoy the lessons that connect the subject with real life situations, which makes STEM more relevant to their life." A university leader pointed out that "that awareness of future STEM jobs must guide decisions regarding more resources for technology and lesson design with practical student learning." More specifically, a university participant emphasized that "engineering skills need to be improved by exposing students to real world problems." Students would benefit from "more math and science practice." A participant recognized that incorporating more hands-on activities will require "restructuring the curriculum and syllabi."

4.3.2 Interview Question 2

Q2- How did the STEM program affect the student's perception in pursuing STEM careers? What is the program doing to support STEM careers? Explain. What kind of initiatives were given to students?

Government Teacher’s/Leader’s Responses:

For the second interview question, the government leaders and teachers agreed on two themes: motivation and awareness.

Regarding motivation, a government teacher explained “student motivation can be increased through recognition such as honoring within the school's motivation system and by creating degrees of distinguished behavior and certificates.” “Even motivational words given by school leaders can go a long way in encouraging students to persist in their STEM classes” as one government teacher stated. Another participant mentioned that “increasing the number of STEM competitions that include an awards ceremony” can also motivate students. Another government leader tied recognition to student projects by explaining how “institutional leaders like the municipality manager awarded gifts and certificates to reward student efforts in their projects.” Recognition can also take the form of “recruitment by universities and then industrial establishments.” One government leader directed student motivation towards STEM careers by explaining how “collaborations with institutions like ADNOC created a half-day or a full-day for students to be part of the institution.” Another government leader also emphasized that “enriching STEM activities can increase student motivation as they organized teachers and student STEM ambassadors to travel to the US for an event.” A government teacher also stated that “explaining the financial rewards of a STEM career” can inspire motivation. Another one suggested “Increase the number of STEM competitions. Include an awards ceremony for the competitions.” Creating “outreach programs that provide information on STEM careers and increase the use of technology related to STEM careers in classes” can be another source of motivation as mentioned by a participant. Additionally, a government teacher pointed out that “engaging projects that connect to STEM careers and provide opportunities for students to explore different STEM careers” can increase interest in STEM.

The second theme that the government leaders and teachers emphasized was awareness. One form of awareness related to future jobs. As one teacher noted, "universities are invited to schools and they advertise their programs, but it is mostly for cycle 3 schools." Another teacher highlighted:

> "More effort needs to be made to increase student interest in STEM education. The students themselves advertise to the public during the morning assembly and in some social places like the park and also in the mall. Students also make films to increase awareness about STEM education."

Industry Teacher's/Leader's Responses

The two themes that the participants from the industry agreed on were motivation and support and funding.

Motivation through STEM can be encouraged by treating the students as scientists. An industry teacher explained:

> "In the workshops, students used satellite photos and worked in their groups to analyse the pictures. In the end, they defended their ideas and thoughts. We treated them as if they were scientists and what they found is appreciated. They were reassured to think that there are no right and wrong answers and that what they found, if it was not true today, might be real in the future."

Students are also motivated by competition and one participant mentioned Hackathon:

> "We need to give them competition and recognition. We need to apply Hackathon that pushes students to learn by themselves and try to apply the skills to win the competitions."

Another participant recognized:

> "There is a link to a skills application. The students in the workshop experimented with different space careers by wearing the space suits and sitting in the control room to move the satellite."

One participant mentioned:

> "To motivate students to pursue STEM careers, industry leaders partner with schools to bring STEM professionals, such as astronauts, to visit schools so that student panels can ask them questions about their careers."

Students can also be motivated by emphasizing the different paths to STEM careers. An industry leader stated that it is important to “help students find the best way to pursue STEM careers.” This can start with “improving communication with parents to increase student STEM participation and to support STEM learning at home.” This can lead to “increasing student awareness of the industry needs and STEM career options.” Additionally, another leader described “a summer space camp was designed for students to build rockets and encourage them to pursue STEM careers by simulating the job of astronauts.” Regarding the second theme of support and funding, one industry leader mentioned:

> “Providing resources can motivate students into STEM careers. We fund universities projects on the condition of having one Emirati student in the working group to encourage them to be in the STEM field.”

Regarding funding, an industry participant explained:

> “Support and funding occur when the institution initiates the collaboration with a university. The collaboration leads to the successful project, the graduation project is financially supported and supervised by the centre, and the successful implementation of the project leads to employment of the students into the institution.”

Another participant said, “Institutions can also accept ideas and proposals from universities that include UAE citizen students to encourage UAE students into STEM careers.” An industry leader stated:

> “Funding is needed in order to support future STEM careers in order to provide internship and mentorship opportunities not only from university students, but also from students at a young age to attract them.”

Funding can also include: “field trips and scientific visits to industrial areas that showcase opportunities in STEM industries.” One industry leader explained that internships allow students to “work with partners in the industry and can motivate students to pursue the appropriate STEM field.” Another participant emphasized that internships provide “shadowing opportunities in industries” and that “partnerships with industries are crucial for future STEM careers.”

University Teacher's/Leader's Responses

Two themes that participants from the university sectors agreed on were motivation and awareness.

To increase motivation, university participants highlighted extracurricular activities. According to one university leader:

> "Camps were designed to increase student motivation to pursue STEM careers. They are given ideas about how to work in robotics and hacking programs in an interesting way. Students also create applications so that they can learn the job of engineers and a software developer."

A university professor described:

> "There is a commitment to extracurricular activities to increase student motivation. The university launched summer programs for online security and another program called Hack in the Box. Four hundred students from schools were active in the program for the first run of the program. For the second run, two thousand students were active. The university collaborated with the institution and the programs focused on stem coding, math and engineering."

In addition to summer camps, another university leader mentioned that "motivation can be increased through scholarships and internships." Several participants underscored the importance of internships by stating that "internship courses can focus on both the theoretical and practical sides" and "expose students to current practices in private sector settings." Internships will also help students to "focus more on practical implementation courses and to connect students with the outside real world" and "practice real-world decision making."

For the second theme, awareness about the STEM program was underscored. One participant mentioned that it "is one of our jobs to introduce the students about what is offered in our university." Another professor suggested:

> "The STEM program specialties could be introduced to the students by a lecture. Afterwards, the students can go around the university to have an idea about the STEM university departments."

To increase awareness in cycle 2 or cycle 3 schools, one university leader said, "our university is accepting school trips to promote what we offer as a department, but not what we need for the future." One participant described their efforts to increase awareness about the links between classes and STEM fields:

> "I can keep an eye on the evolving needs in my field and look for solutions through research. I can then disseminate my findings to my students and other institutions for implementation; Teaching, research, collaboration and dissemination of knowledge to develop student interest. As an active reader and researcher, I can help to promote STEM careers. By increasing student interest with my research background, I can highlight the real-life links between STEM research and development and the students' classes."

4.3.3 Interview Question 3

Q3- Does your institution use collaboration to serve the STEM program in the public school? Describe your collaboration and what was gained from it. What is the importance of the collaboration between school -university- institution? Explain.

Government Teacher's/Leader's Responses:

For the third interview question, two themes that resulted from the government cluster's perceptions were collaboration and integration. One government leader noted the importance of collaboration and mentioned that "more collaboration was needed to make the dreams of the students true." Another participant said:

> "In order to honor the students' efforts, we need to collaborate with industries and universities to prevent wasting student ideas. We need to make the proposals of the students true."

Collaboration can also take the form of partnerships with different institutions. A government teacher pointed out that "the inclusion of a summer course as a practical course for students in companies specialized in this field" can increase STEM motivation. STEM interest can also be increased through "workshops that explain STEM benefits to students," with the outside institutions in attendance." Another government teacher highlighted that cooperation, such as career counselling, was necessary "to improve the STEM program."

Other participants mentioned that collaboration was necessary “to design meaningful courses” and that “the input of universities and industries should organize continuous meetings to discuss improving the STEM program.” A government leader suggested a collaboration between cycle 2 schools and universities by including “a project as a requirement for admission to universities for high school students, such as IELTS and EMSAT. This will increase STEM's importance.”

To better integrate STEM education, one government teacher mentioned “schools and universities need to collaborate to know what is the new vision for STEM education.” Collaboration with outside institutions for the benefit of STEM education was also specified. Several participants emphasized the need for communication to improve STEM integration. One government school leader stated that “more communication can help students explore STEM careers and know the foundations and basic requirements they need”, while another government school leader stated that “creating a calendar that includes the availability of the assisting bodies and institutions” can improve the connection between STEM classes and STEM careers. The effort to highlight the real-world application of STEM fields was a priority when improving STEM integration for one participant and they suggested “creating a direct communication link between the schools applying for the project and the experts working in relevant fields.” Similarly, another participant mentioned that it is necessary to “increase communication between schools and STEM fields.” One participant stated, “students received great encouragement and praise for the excellence of the projects and institutions even mentioned the possibility of benefiting from them in the future,” as well as providing benefits for their STEM career goals. Communicating with parents was also specified and a government teacher suggested advertising “the program in schools for students to join and train parents how to follow up on their children.” One government leader highlighted that “opening different types of communication channels makes it easier for everyone to stay informed on relevant STEM information.*"* Another participant added that "establishing a network between universities and schools so that more students can become involved in STEM programs." By "communicating with specialized colleges and related institutions, schools can facilitate students' STEM learning experiences (through workshops, courses, etc.)." When cycle 2 schools communicate with other institutions supporting STEM, STEM integration can benefit because it "helps motivate students to understand the requirements of future occupations and prepare students for university education." Additionally, the institutions can "help to standardize student outputs at the high school level."

University Teacher's/Leader's Responses

For the university participant cluster, two themes that emerged were social impact and support for the third interview question. Regarding the social impact theme, one university participant described:

> "For the school students from cycle 2 and 3, I was responsible for the projects of talented students. There was collaboration between university, government and institutions for teaching students the skills to solve the problems. At the end of the program, the students completed a project using the skills that they learned such as making hardware and software for Encryption."

Additionally, government students have opportunities to participate in programs that have social impact through summer camps and programming projects, as mentioned by another participant. One university professor mentioned:

> "Our internships have a social impact. We have internships with institutions and universities that provide opportunities in satellite security with space agencies and projects with RCA (router communication authority) for autonomous car security."

One participant detailed the benefit of STEM social impact programs:

> "Engineering for social impact programs so we send students from the university to industrial countries to study some of the university courses for more skills and gain knowledge and experience from other countries."

A university leader also mentioned that “strong linkages between on-the-job STEM training and research and development” can lead to positive social impact because they can find solutions to certain problems.”

In terms of the second theme, support, a university participant acknowledged, “more resources are needed to train students on how to use technology since they are trying to interest younger students into STEM education and careers.” Another participant mentioned, “training is also needed for IT teachers, which also requires support.” Additionally, “student participation in STEM competitions is lacking necessary resources to complete their projects”, which was stated by a university professor. Support can also come from other institutions as one university leader highlighted the need “to implement more collaborative links with private organizations and to increase communication with private industries” so that the STEM curriculum can “incorporate the needs of the labor force into the students' education.” Several participants emphasized the need to support the students’ STEM career interests. For instance, one participant said it is important to

> “Increase the students' awareness of STEM careers. More communication will give students more access to STEM career information. More communication can also develop practical skills for industry needs and support student training with technology. Regular coordination with industry is also needed so that students can have practice with solving real world problems.”

Industry Teacher’s/Leader’s Responses:

Two themes emerge from the university cluster regarding the third interview question, and they were funding and support and social impact.

One industry leader acknowledged their funding and support for students, “Our institution supports university students in many ways. We fund the projects submitted by any institution or projects submitted by the university.”

One outcome of funding is providing resources for students for their projects. One participant mentioned:

> "A good example is when the institution initiates the collaboration with the universities and financially supports the students. For instance, it can end with an invention such a "space satellite" like the one completed by a group of students for their graduation projects."

Several participants pointed out the need for industries to support STEM education. One industry leader highlighted that industry professionals "provide a positive role model for students through job fairs." Another industry teacher suggested "creating professional development to improve STEM instruction by making it more engaging for students." Industries can also "participate in conferences by holding discussions" and "work to increase student internships" as two other participants pointed out.

For social impact, the second theme, the participants mentioned their role in improving communities. One participant mentioned how their institution prepares students for the workforce:

> "As an institution our vision focuses on building innovative and industrial workforce generation for the future. We train students in skills such as carpentry to create creativity, 3D printing, coding programs. We visit schools, universities and institutions. We provide workshop services and introduce the skill to students and society."

Another participant listed the ways their institution provides practical training to benefit the community:

> "Our institution provides services to the community for all members of society. We focus on providing modern services. All our equipment is modern and new. Diversification and modernization are important in our services and it needs to meet the industry goals for the future, which are concentrating on courses such as digital sewing, modern programming and robotics and coding. Additionally, the institution focuses on manufacturing motherboards, prototypes, welding and all industrial services."

Institutions also play a role in supporting STEM education to support the future economy. One industry leader said, "We invite experts from outside the country and offer competitions for school students to solve problems through drawing."

4.3.4 Interview Question 4

Q4. What are your suggestions to improve the STEM program which can encourage students to pursue STEM careers in the future?

For the fourth interview question, the three themes that were extracted from the participants from the government cluster were collaboration, curriculum and motivation. The government leaders and teachers concentrated on the communication with other institutions to support student learning as one of the leaders said, “Our main focus in the future planning is to collaborate with universities and institutions to benefit the students in the STEM program.” One participant stated that a more structured approach was needed to appropriately support the STEM program and “The initiative of the collaboration with the universities and institutions comes from the school teachers and leaders, and we need a system for this support.” Collaboration with other institutions can improve teacher training programs by making them relevant. Through partnerships with universities and industries, two participants mentioned that continuous teacher training can help “teachers to prepare students for universities” and help “teachers to learn more about the STEM industry.” On the other hand, for some teachers, communication with other institutions is not allowed. One teacher mentioned, “We are controlled, and we don't have the right to collaborate with universities and institutions.”

Regarding the second theme, one government teacher participant identified the challenges of implementing the STEM curriculum and stated, “I think there should be new schools for STEM or create a new track for STEM in the schools so that it is more focused and concentrated.” More specifically, a government leader suggested “creating a special curriculum for the STEM program embedded with the curriculum for each subject.” Regarding the teaching workload, one government participant remarked, “We need a ready-made curriculum for STEM with the program so it will be easier for implementation which reduces time and effort." Several government participants spoke about the challenges of the STEM curriculum. One teacher elaborated that "the STEM curriculum is long" and another teacher pointed out that "STEM takes time to implement, and the STEM program is an extra part of our curriculum with no incentives." Therefore, it is necessary to "teach STEM in all curricula, not just scientific curricula," as mentioned by another participant. A participant explained the benefits of "creating a separate STEM class in order to create a curriculum with a strong base in scientific subjects." Additionally, a government teacher pointed out that "more interactive computer programs with STEM" can improve students' skills by "making the lessons engaging and fun." Another government teacher highlighted the importance of creating a relevant STEM curriculum by "connecting it to the job market and working with STEM industries to collaborate on curriculum." Additionally, one government leader suggested, "Matching the curriculum to the needs of the labor market ensures that the curriculum is compatible with STEM requirements."

For the third theme, government participants discussed different forms of motivation for students. One teacher emphasized the importance of incorporating behavior grades in STEM education:

> "Teachers from government schools need a motivational system that celebrates STEM student achievements such as awarding students for earning grades for behaviour. This will make the program more important for both students and parents. Many parents and students are complaining that working on STEM projects takes a long time. This effort is usually used in other subjects which have grades."

Another government teacher suggested "assigning stages to the STEM program" that enables "the student to rise to a higher stage according to his/her progress. To increase student motivation, one government leader recommended "creating more hands-on activities and including more scientific field trips aimed at scientific research." Similarly, other participants highlighted "creating projects with real-world applications for students."

To incentivize students, one government leader considered using “practical study and institutional visits as training hours for the student.”

University Teacher’s/Leader’s Responses:

The theme that emerged from the fourth interview question from the university participants was motivation. One university emphasized “the need for enrichment learning opportunities. This can take the form of clubs and science fairs.” To keep their interest in STEM, one university professor highlighted that “students need challenges and competitions where they have only a short time to learn the skills and apply the skills to compete and win.” One university participant noted that “increasing incentives for students enrolled in the STEM program will increase their motivation.” To support these STEM learning experiences, one university professor suggested that “universities and institutions need to support more STEM schools.” One university leader said:

> “Motivation can also take the form of awareness and a special team can be created for STEM. This STEM team can create simple exhibitions to spread the idea of STEM among institutions, universities and students.”

Linking STEM to future careers can also be motivating and one university professor said, “it will be useful to spread awareness to parents regarding new STEM jobs so that they can encourage their children to study subjects like Maths and Physics.”

Industry Teacher’s/Leader’s Responses:

Participant perceptions from the industry cluster agreed on three themes: support, curriculum and motivation. For the first theme, one participant recognized:

> “More resources are needed to provide students with the tools to create innovative STEM projects. Schools need to be equipped with innovation labs in each Emirate and a STEM laboratorian should be available to help students create prototypes.”

Supporting student projects was a concern for many of the participants. One industry leader agreed and pointed out, “collaboration with universities and industry is needed to help and support the students' projects which can attract students for STEM jobs in the future.”

Industry leaders and teachers also corresponded on the theme of curriculum. In order to attract students, one industry leader suggested:

> "A special track system for stem education in the school is needed. Additionally, ready-made STEM activities in the curriculum should be available for teachers to implement the new STEM track in the school. It would make the program more effective."

To improve curriculum, one industry teacher recommended that "more collaboration with universities is needed to reduce the employment gap of future STEM careers."

For the third theme of motivation, industry participants communicated that more efforts were necessary to support STEM education. One industry teacher explained:

> "There are benefits to a tracking system. Creating a student database is important because establishing a tracking system to follow the success of talented students until they reach their future careers can be very encouraging for the students."

Another industry participant emphasized increasing student engagement by "increasing their interest with more student competitions, more student incentives and more rewards." Another industry teacher highlighted that "learning must be relevant so that students are inspired to learn. This requires cooperation with external institutions such as universities."

4.3.5 Summary of Results for Research Question 3

The following Table 4.51 summarizes the **t**eacher's/leader's responses of the government cluster, industry cluster and university clusters participants perceptions regarding the four interview questions related to the Triple Helix model to benefit STEM education and STEM careers, as well as their perceptions and suggestions for improving the implementation of STEM education.

Table 4.51: The Interview Summary

Interview Questions	Summary of Results (Categories)
Q1. Why do you think STEM (science, technology, education and math) education in the UAE is preparing students for future industry needs and future vision 2030?	• STEM education will support the vision of the country • STEM needs to build 21st century skills • STEM education needs hands-on activities to make it easier to understand for the students • The set of 15 Government School officials and 7 industry specialists and 7 university experienced leaders in their fields and their opinion have identified that the STEM would be increasing the skill set and the hands-on experience of the students. • There is a need for technology to build student skills for future careers • The better understanding of the students will be made if they went through the internship and apprenticeship programs and got hands on while they were studying. In this way, everything will be much more effective in order to obtain the desired results required from the STEM Program. • Continuous feedback, motivational skills and practice strategies to narrow the gaps in their learning • Collaboration to revise and improve STEM curriculum so that it is updated
Q2- How did the STEM program affect the student's perception in pursuing stem careers? What is the school doing for this purpose?	• Motivation from all Triple Helix clusters is needed to support students to pursue STEM careers • Awareness can also lead to a higher level of student motivation • Industry can provide support and funding for STEM education

explain. What kind of initiatives were given to students	
Q3- Does your institution use collaboration to serve the STEM program in the public school? Describe your collaboration. What kind of collaboration has been made between universities or institutions and schools? Explain please. And what was given from their side?	• Collaboration is needed between the three Triple Helix clusters to benefit STEM education to increase student motivation • Institutions benefit from STEM student's innovation • Solving real world problems in STEM can benefit the society • Collaboration comes in the form of funding STEM education • More collaboration and funding needed to support students' STEM projects • Collaboration between institutions to provide students with new technology is needed
Q4. What are your suggestions to improve the STEM program which can encourage students to pursue STEM careers in the future?	• More collaboration between Triple Helix clusters • Initiatives mainly comes from schools and it needs to be embedded in STEM policy • Regulations are obstacles for teachers to collaborate • A new school for STEM for greater concentration • Create a new curriculum with STEM embedded in each subject to make it easier for teachers • More recognition for student achievement in STEM • More resources (such as labs in each Emirate) to support students' STEM projects

	• Create a database to attract students at a young age and support their STEM learning until they are employed in a STEM career • More enrichment programs (clubs, fairs, etc.) • More competitions for motivation

CHAPTER 5: Discussions, Conclusions, Implications, Recommendations and Limitations

The final chapter of the study focused on presenting the discussions, conclusions, implications, recommendations and the limitations of the study. In this chapter, the researcher examined and elaborated on the research findings to each research question individually. The chapter included interpretations of the research findings to suggest STEM policy recommendations that use the Triple Helix model to benefit STEM education and STEM careers to promote the UAE's Vision 2030.

5.1 Discussions

The purpose of the study is to investigate the common themes related to the formal and informal STEM education and stakeholders' perceptions and responses on formal and informal STEM education programs, STEM careers and the Triple Helix model in the UAE. To achieve the purpose of the study, the researcher examined the findings from the following three research questions:

> **RQ1:** What are the common themes associated with the formal and informal STEM education programs to benefit the UAE?
>
> **RQ2:** What are the perceptions of stakeholders on the formal and informal STEM education programs, STEM career choices and the Triple Helix components?
>
> **RQ3:** What are the stakeholders' responses on the connections among the Triple Helix components with formal and informal STEM education programs and future STEM careers in the UAE?

The research was conducted using exploratory sequential mixed method design. The findings of this study are based on document analysis, stakeholder questionnaires and Leaders/Teachers semi-structured interviews. The questionnaire results were obtained from the three Triple Helix clusters: government, industry and university. From the government cluster, 6 government schools participated, which included: 123 STEM teachers, 361 students and 101 parents. The industry cluster included 110 students from middle school to university level and 53 teachers. From the university cluster, the sample included 101 students and 54 teachers. The participants for the semi-structured interviews included: 15 teachers and leaders from government schools, 7 teachers and leaders from the industry cluster and 7 teachers and leaders from universities.

5.1.1 Discussion of the Results of Research Question 1

RQ1: What are the common themes associated with the formal and informal STEM education programs to benefit the UAE?

Using document analysis, the researcher investigated the extent that the themes related to formal and informal STEM education programs, themes related to future careers in the UAE and themes related to the Triple Helix model link to the UAE's 2030 Vision and align with its focus on future STEM careers. The literature agrees and details to that effect can be found in the next section

First, the researcher analyzed policy documents using thematic analysis. The researcher examined and interpreted themes regarding how different countries implement STEM education programs. Patterns in the data were found using Braun and Clark's (2006) six steps for thematic analysis. For Step 6, the "Results" section of this chapter was written. By analyzing the STEM education policies, the researcher discovered the common trends in successful implementation of STEM education programs in Australia, Ireland and the US.

Themes related to both formal and informal STEM education programs were found during the document analysis. In terms of the themes related to formal STEM education programs, the Science, Technology & Innovation Policy in the United Arab Emirates focused on developing STEM skills to attain outstanding educational achievements. In

Charting a Course for Success: America's Strategy for STEM Education, dynamic activities that fostered identity development through science curricula was mentioned. The document also promoted student advisors in schools to provide support and guidance in formal and informal STEM education programs and STEM careers. The STEM curriculum that is designed to incorporate relevant learning connections should be project-based and student-centered, which was emphasized in a study conducted by Williams (2016). In terms of themes related to informal STEM education programs, creating partnerships with businesses that connect schools and work should be a priority, according to Challenges in STEM learning in Australian Schools. The Science, Technology & Innovation Policy in the United Arab Emirates policy paper pointed to integrating science, business and technology through investments from different sectors. Also, charting a Course for Success: America's Strategy for STEM Education stated that industries should become more involved by developing clear career opportunities for new recruits. The findings in this research identified 18 themes from the document analysis that were mentioned as essential Triple Helix components for implementing STEM education programs. Table 5.1 provides the complete list of the three final themes and the coded features of the policy documents that support it. The three categories that the researcher used to organize the themes were: themes related to formal and informal STEM education programs, themes related to future STEM careers and themes related to the Triple Helix model and STEM education programs and STEM careers.

Table 5.1: Summary of Themes from the Document Analysis

Themes Related to STEM and Education Policy
1. Technology in Education
2. Creativity and Problem Solving
3. Transfer of Knowledge
4. Skills Development
5. Improving Outcomes

6. Promoting Internships and Industry Practice 7. Incentives for Students and Teachers
Themes Related to Career 1. Better Outcomes and Incentives 2. More Apprenticeships and Hands on Experience 3. Attracting and Retaining Best Minds 4. Ability to Apply Skills 5. Preparing Students to Meet Industry Needs 6. Integrate Technology in Curriculum
Themes related to the Triple Helix Model 1. Consulting Stakeholders Involved 2. Emphasize Public Private Partnerships 3. Involve Stakeholders in Curriculum 4. Promoting Leaders in Education 5. Coordination and Communication of Universities, Industries and Schools

The researcher used the following three categories to organize the themes because the document analysis highlighted that STEM education programs, STEM careers and the Triple Helix components were important in the STEM policies of countries ranked high in STEM. Similarly, the three categories were also highlighted in the literature. In order to meet the changing demands of the workforce, STEM education increases the students' skillset (Litchfield & Dempsey 2015; Petersen et al. 2018). Developing these skills will enable creativity and innovation in all sectors (Mohammed Bin Rashid School of Government 2015). The UAE government understands the importance of developing the knowledge-based economy and expanding Emirati participation in the workforce. Therefore, increasing the quality of STEM education is a priority (Mohammed Bin Rashid School of Government 2015). With the Triple Helix model, the interactions among innovation actors (government, university and industry) support countries in enhancing and accelerating their knowledge-based economies (Halibas et al. 2017). The researcher used the three categories (STEM education programs, STEM careers and the Triple Helix model) to create the questionnaire to measure stakeholder perceptions and answer the research questions.

The themes pertinent to informal and formal STEM education programs came out to be technology usage in education, providing internship opportunities and industry practices, creativity and problem solving, transfer of knowledge, skills development, outcome improvement and providing incentives to the teachers and students. These themes are in line with Kasza & Slater's (2017) findings which mentioned that STEM education develops the students' 21st century skills through STEM's problem-based approach. Wiebe et al. (2018) also emphasize that STEM education must provide students with relevant experiences to increase STEM education outcomes. The constructivist learning approach is supported by STEM due to its emphasis on student driven learning (Samsudin et al. 2020) 2018). From the document analysis, the career related themes identified are better outcomes and incentives, more apprenticeship techniques, recruiting and retaining the best talent, enhancing the ability to apply skills, preparing the students to meet industry demands and integrating technology in the curriculum. Gamse, Martinez and Bozzie (2017) note the benefits of internships since they can help to support STEM engagement. Regarding technology in the STEM classroom, developing digital competencies enables students to take on more active roles in their learning (Sen, Ay & Kiray 2018). From the Social Cognitive Career Theory perspective, the students' external environments can influence individual behaviors (Hackett 2002). Accordingly, internships and competency in technological tools can develop self-efficacy and facilitate a students' path to a STEM career. The themes related to the Triple Helix model are consulting the stakeholders involved in the implementation of the STEM education programs, promoting public and private partnerships, involving the stakeholders in updating the curriculum, promoting leadership in the education and streamlining the coordination and communication between the institutions. Furthermore, Appelt et al. (2016) underscored how these university and industry linkages can result in boosting economic growth. For instance, these beneficial public and private partnerships can take the form of job-readiness training (Andree & Hansson 2020). Such associations between the Triple Helix clusters can improve learning, as supported by the EARTH design (Mandrup & Jensen 2017). As a result, the 18 themes identified in the document analysis can benefit the formal and informal STEM education programs in the UAE.

These 18 themes relate or connect to the theoretical framework mentioned in the literature: Institutional Theory, Social Constructivism Theory, Social Cognitive Career Theory (SCCT), the emphasis on collaboration between the Triple Helix components (industry, university and government) and EARTH design. Institutional Theory asserts that transformation is only possible through collaboration, making communication between the Triple Helix clusters mandatory. Social Constructivism Theory and SCCT emphasize how external factors shape learning and influence career choices, highlighting the need to design STEM education programs to be engaging and relevant. Lastly, institutional partnerships between the Triple Helix clusters provide a means to improve STEM education by including the stakeholders involved.

5.1.2 Discussion of the Results of Research Question 2

RQ2: What are the perceptions of stakeholders on the formal and informal STEM education programs, STEM career choices and the Triple Helix components?

The second research question aimed to investigate stakeholder perceptions on the formal and informal STEM education programs, STEM career choices and the Triple Helix components. To address this research question, quantitative data was collected through a questionnaire distributed to the stakeholders in the three clusters (government, industry and university).

From the data analysis, the perceptions within clusters compared the perceptions of all stakeholders from the Triple Helix clusters in the three categories: educational programs, future STEM careers, and the Triple Helix. The second analysis is perceptions between clusters. This means looking through all the perceptions of leaders/teachers and students from the government, university, and industry in the three categories. Figure 5.1 presents the division between the two perceptions. Figure 5.2 shows the descriptive analysis for perceptions within clusters. All stakeholders from the three clusters perceived all three categories positively. Figure 5.3 presents the descriptive analysis for perceptions between clusters. There were differences between the leaders/teachers and students from the various Triple Helix clusters.

Figure 5.1: Stakeholders' Perceptions (Within and Between Clusters)

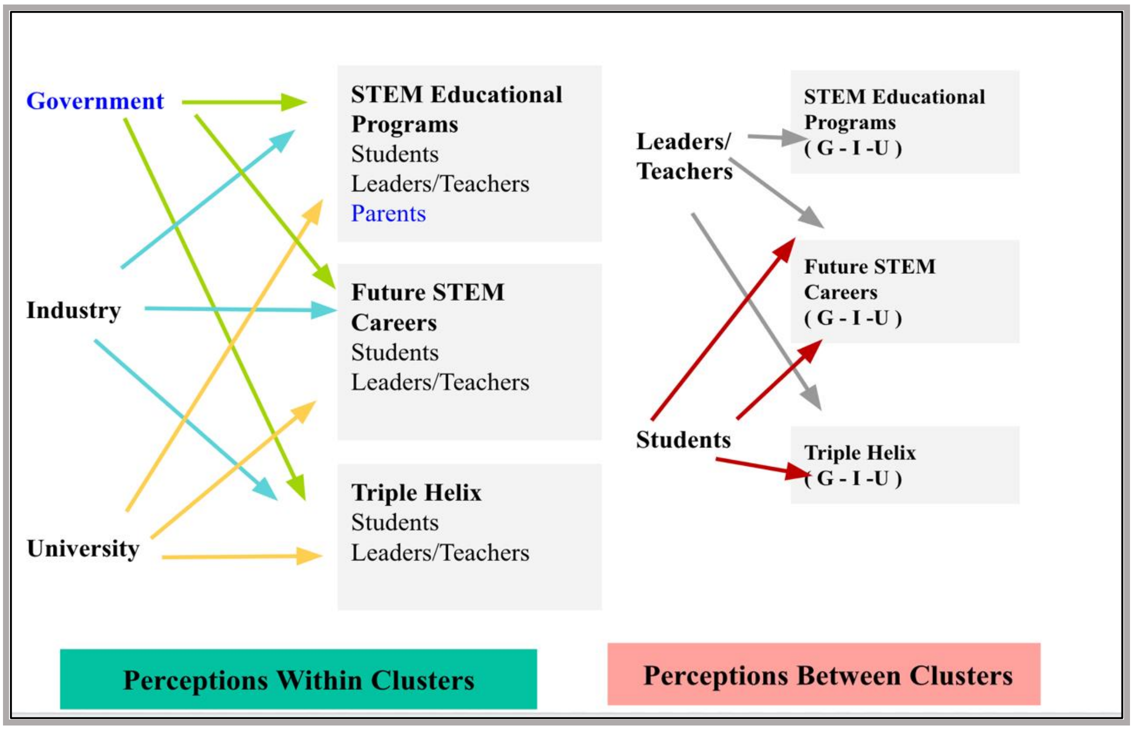


Figure 5.2: Descriptive Analysis Summary of Stakeholders' Perceptions (Within Clusters)

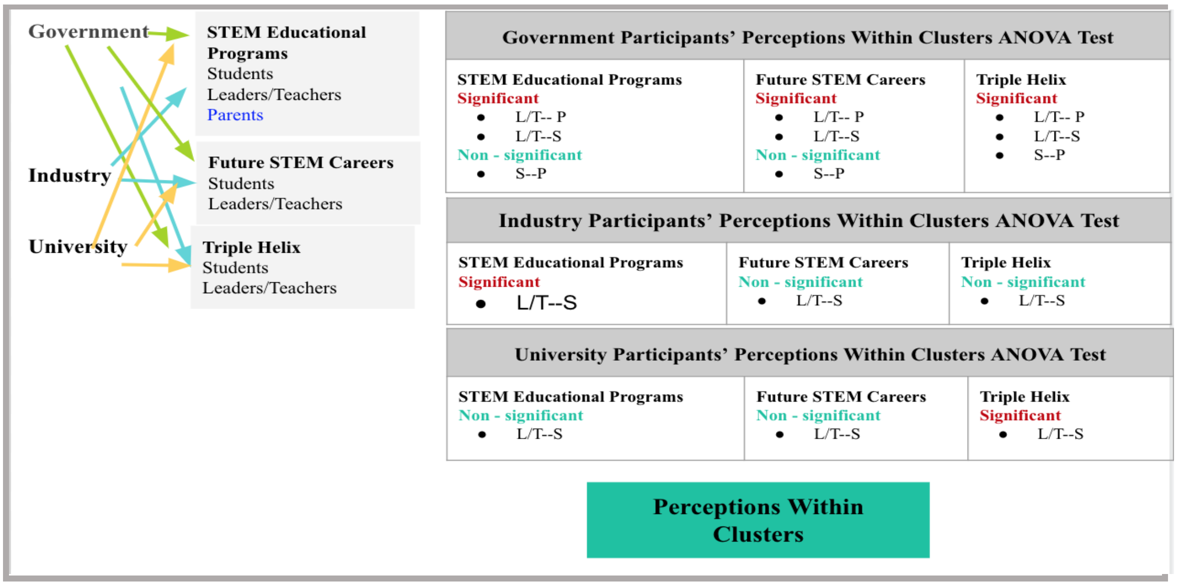
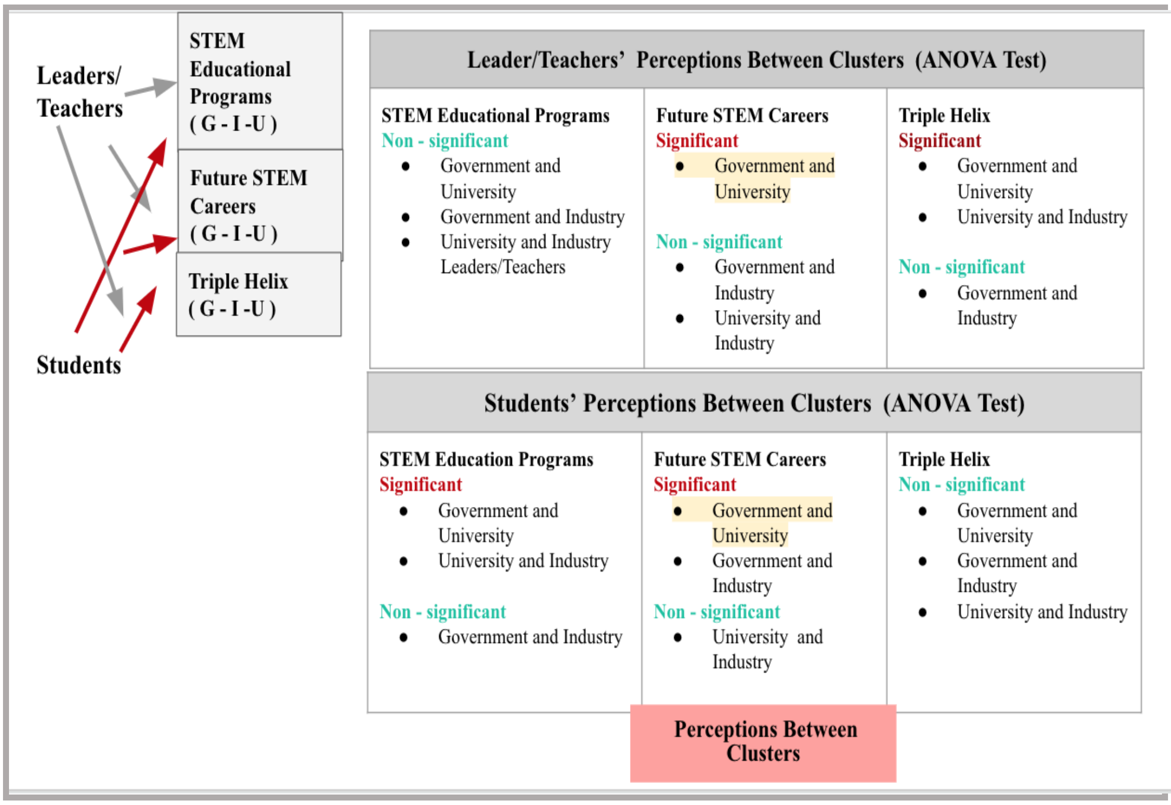


Figure 5.3: Descriptive Analysis Summary of Stakeholders' Perceptions (Between Clusters)



5.1.2.1 STEM Education Programs Perceptions

The stakeholders highlight the importance of formal and informal STEM education programs and STEM careers. The results of this research question are in line with the findings of Nguyen, Nguyen and Tran (2020) who found that the teachers who are interested in applying the STEM education system view it as an important approach that provides an opportunity to enhance their role as teachers and address the challenges of developing STEM careers in their country. This link between investing in STEM education programs to develop the economy was seen in the perceptions of the governmental schools' teachers, students and leaders. The teacher/leader participants from all three clusters, industry students and university students very highly agreed that informal and formal STEM education programs prepared the students to meet the future industrial needs. Government parents and government students highly agreed on this matter. In a STEM classroom, the social constructivist approach utilizes scaffolding and collaboration to help students to mature through levels of understanding (Achzab, Budiyanto & Budianto 2018, Admawati, Jumadi & Nursyahidah 2018). This is in line with the British Council (2018) which advises that the curriculum needs to be adjusted to remain focused on students' 21st century skills and needs. When designing formal and informal STEM education programs, activities that are more hands-on and engaging can lead to an increased interest in science and future STEM careers (Popovic & Lederman 2015; Roberts et al. 2018).

El-Deghaidy and Mansour (2015) also found that the preparation of the teachers was a requirement for the successful implementation of STEM education and achieving its desired outcomes. Accordingly, professional development of teachers for the successful implementation of STEM education was emphasized. Best practice for professional development for STEM teachers has been provided in different forms such as practicum extension and field placement for teachers (Müller et al. 2015; Jenset 2017), teacher training schools (Canrinus et al. 2019) and partnerships with university schools in Norway (Lund & Eriksen 2016). There was an emphasis on the importance of teachers preparing students for industry needs in STEM education programs. According to Social Constructivism, it is specifically the interactions between individuals that enables knowledge to be formed (Williams 2017). The level of teacher quality impacts the quality of student learning. For STEM learning environments, educational leaders help to increase students' STEM achievement (Kupersmidt et al. 2018). Habig et al. (2020) highlighted the relationships that students established with adults as a factor in their persistence in STEM education and/or a STEM career trajectory. Figure 5.2 highlights that leaders/teachers from the government and industry clusters are agreeing with other stakeholders on STEM educational programs whereas leaders/teachers from the university clusters have differences in perceptions. The non-significant difference in the university cluster is worth investigating in the future.

For students to meet the industry needs, 21st century skills comprise of key competencies that will help them to thrive. The student participants in the three clusters highly agreed on the importance of these 21st century skills. These participants highlighted the importance of integrating technology in formal and informal STEM education programs. The participants also agreed that problem-solving was an important skill to develop, which can be assisted through the integration of technology. These findings are in line with Yang and Baldwin's study (2020) that viewed technology-use strategies as tools that extend beyond traditional teaching. Thibaut et al. (2018) points out that developing digital competencies is embedded in STEM education. STEM prepares students with 21st century skills by employing technology as a supportive tool to learn with (Petersen et al. 2018; Darling-Hammond 2017; Pasnik & Hupert 2016). The importance of technology in informal STEM learning environments is also emphasized as they create challenging activities requiring the use of technology to help students advance in their future careers with the needed 21st century skills (GMIS 2019).

Across all three clusters, there were no differences between male and female STEM Perceptions and STEM Career Perceptions. According to Radloff and Guzey (2016), the students' social and cultural environment all play a role in facilitating STEM education programs through social learning. For instance, a student's home life plays a major role in their learning and development (Peterson 2017) as parents transmit parents core values (Ceglie & Setlage 2016). Additionally, Anderhag et al. (2016) emphasizes the power of classroom experiences to establish science identities. The students' social and cultural environments may have served as factors that influenced their positive perception of STEM education. This contrasts with the literature highlighting the STEM gender gap. According to the World Economic Forum (2019), the average gender gap is also prevalent in STEM education and careers. Lent et al. (2008) describes the Social Cognitive Career Theory (SCCT) identifies measures of self-efficacy, outcome expectations, personal backgrounds and inputs and contextual support and/or hindrances to explain the logic behind students' career/academic choice. SCCT is used as a predictive model of interest in the STEM fields for students in the Cycle 2 and Cycle 3 levels (Lent 2005; Lent et al. 2008). Therefore, social and motivational factors can be cited as influencing the students' perception of STEM careers (Nugent et al. 2015). Figure 5.3 demonstrates that leaders/teachers and students from the government and university clusters positively agree on future STEM careers. However, perceptions of these stakeholders from other clusters need further investigation in the future.

5.1.2.2 STEM Career Perceptions

Regarding STEM career perceptions, all stakeholders highly agreed that STEM education programs will benefit a student's future, including their career. Schultz and

Schultz (2016) identify individual goals as a factor that influences students' career choices. Green and Sanderson (2017) identified motivation in school can increase persistence in pursuing a STEM career. According to SCCT, goals take into consideration both personal interests and self-motivation (Lent, Brown & Hackett 2002; Leong 2008). As a result, a student's motivation can be a deciding factor as to whether they pursue a STEM career. Additionally, Milner-Bolotin and Marotto (2018) emphasize that a child's achievement in STEM education can improve from parental engagement. The leaders/teachers and students from the governmental and university clusters very highly agreed that rewards and awards contribute to attracting and retaining the best minds. Recognition from the community is emphasized as a motivating factor. It is advised that parents are active participants in their child's school life to help them succeed in STEM education's student-centered approach by joining in on the hands-on activities (First Lego League 2020). Lent et al. (2008) describes the Social Cognitive Career Theory (SCCT) identifies measures of self-efficacy, outcome expectations, personal backgrounds and inputs and contextual support and/or hindrances to explain the logic behind students' career/academic choice. SCCT is used as a predictive model of interest in the STEM fields for students in the Cycle 2 and Cycle 3 levels (Lent 2005; Lent et al. 2008). Therefore, social and motivational factors can be cited as influencing the students' perception of STEM careers (Nugent et al. 2015).

Also, Shattock (2009) states that curriculum should focus on requiring students to use their own knowledge to create innovative solutions. The participants also highly agreed that problem-solving is an essential skill that should be developed in STEM education programs. These initiatives can improve both social and economic development, but they need support, which requires the communication between external and internal partners (Scharmer & Käufer 2000). The EARTH design explores educational designs that require the involvement of collaborative actors from various sectors (D'Este & Perkmann 2011).

5.1.2.3 Triple Helix Components Perceptions

The leader/teacher participants in all clusters and governmental parents highly agreed on the benefits of the coordination and communication of universities, industries and the STEM education program. The collaboration can contribute to professional development and student skills development. With the Triple Helix model, relationships between the different institutions can be improved so that developments can reach across the other clusters (Ranga & Etzkowitz 2013; Rodrigues & Melo 2013). For instance, Etzkowitz and Zhou (2017) express that entrepreneurial universities can foster social and economic development through research and the production of intellectual property.

Etzkowitz (2008) emphasizes that improvement can be supported by the collaboration between the Triple Helix actors. More specifically, the educational sector can benefit from the development spurred by Triple Helix partnerships. Ranga and Etzkowitz (2013) state that the Triple Helix actors support students’ entrepreneurial talent by cultivating 21st century skills, contributing to economic development. Also, Karmokar and Shekar (2018) emphasize that Triple Helix partnerships motivate students to seek future STEM jobs. The participants mentioned that enhancing practical STEM activities for students and providing guidance for students’ future career choices are opportunities for the Triple Helix components to benefit STEM education programs and STEM careers. Raising students’ and parents’ STEM awareness was also underscored by the participants. Dickson, Fidalgo and Cairns (2019) highlighted that students benefit from STEM awareness at a young age because it increases their interest in STEM.

The leader/teacher participants from all clusters and governmental parents highly agreed on the need for ongoing and strong collaboration among the Triple Helix actors. This is not always easy and studies have pointed out that collaboration among the Triple Helix actors faces barriers (Karmokar & Shekar 2018). Desai (2018) mentions that disagreements and disputes can arise from clashing needs and objectives between the Triple Helix actors. These barriers need to be overcome since it is through the collaborative synergies among the Triple Helix actors that increase innovative development (Etzkowitz 2008). Sustainable partnerships with strong communication channels, which are simultaneously autonomous and overlapping, can withstand the environmental conditions that can make the partnerships vulnerable (Desai 2018; Etzkowitz & Zhou 2017). Communication removes the boundaries between the Triple Helix actors, which can benefit STEM education programs through organizational creativity (Etzkowitz & Zhou 2017). Chryssou (2020) recommends that incentives for Triple Helix members can facilitate communication, collaboration and joint initiatives. Similarly, Institutional Theory also reinforces the relationship between communication and change. Peters (2019) underscores that it is the discourse between the institutions that makes development possible. In addition, Cai and Liu (2020) draw attention to the dynamic interactions between Triple Helix members that drive innovation in society.

Figure 5.2 indicates that regarding the Triple Helix, it is only the stakeholders from the industry cluster that are showing non-significant differences in perceptions, which points to a need for further investigation.

5.1.3 Discussion of the Results of Research Question 3

RQ3: What are the stakeholders' responses on the connections among the Triple Helix components with formal and informal STEM education programs and future STEM careers in the UAE?

This section sums up the ways that the Triple Helix components can benefit formal and informal STEM education programs and help to support future STEM careers according to the leaders/teachers perspectives from the three stakeholder clusters (government, university and industry). Stakeholder responses from the four interview questions are discussed.

The Triple Helix components benefit STEM education through collaboration. For instance, providing resources for STEM projects was highlighted by the participants. One industry participant summarized, “A good example is when the institution initiates the collaboration with the universities and financially supports the students.” Financial support can create STEM enrichment learning opportunities such as clubs and science fairs. The participants called attention to the need to promote STEM extracurricular activities and one university professor highlighted that “students need challenges and competitions where they have only a short time to learn the skills and apply the skills to compete and win.” To support students’ STEM projects, a government stakeholder also mentioned that “more collaboration was needed to make the dreams of the students true.” It was noted by a university professor that students participating in STEM competitions “lack necessary resources to complete their projects.” By collaborating with institutions such as industries and universities, STEM programs can “honor the students’ efforts” and prevent “wasting student ideas”.

Support can also take many different forms of partnerships with various institutions. A government teacher pointed out that summer courses in STEM fields can increase STEM motivation. Additionally, participants pointed out the need for industries to support STEM education. One industry leader highlighted that industry professionals can “provide a positive role model for students through job fairs.” Collaborations with industries can also result in “creating professional development to improve STEM instruction by making it more engaging for students.” To promote student learning, there is a need to equip teachers with the required skills to enable them to impart knowledge and competencies to the students (Hardin & Longhurst 2016). The findings of this study are based on the tenets of Social Cognitive Career Theory which states that the context of social interactions, such as the enriched STEM learning environment created by the coordination among the Triple Helix clusters, impacts the students' knowledge acquisition. The university teachers and leaders suggested that improving STEM education requires improving the professional training for the implementation of the STEM programs. Professional development can be used to train teachers to employ the modern pedagogies, as well as to modify and update the curriculum according to the modern techniques and trends to improve students' understanding of STEM subjects. With the Triple Helix model, issues mentioned by the stakeholders related to aligning STEM curriculum to future industry needs can be resolved.

Strong communication channels created through the Triple Helix components can be streamlined for the effective exchange of the information regarding the implementation of STEM education among all the stakeholders. The stakeholders also suggested that a network between the universities and schools can help the students to get involved in professional training and development programs. Also, the communication between these institutions can help to organize field trips and seminars to engage students in STEM learning. Carlisle and Weaver (2018) stated that by centralizing the STEM activities, the communication and partnerships can be enhanced. Also, Rodrigues and Melo (2010) state that improving the coherence between different institutions, through the Triple Helix model, can improve development. Related to EARTH design, Mandrup and Jensen (2017) point out the diversity of actors present in the Triple Helix model promotes student learning.

The Triple Helix components benefit students' future STEM careers through 21st century skills. The stakeholders emphasized the importance of STEM education to prepare students for future jobs with the help of the Triple Helix model by developing 21st century skills that practice “exploring new and creative ways of problem-solving, displaying data, innovating and linking multiple fields”. An industry participant emphasized the need to include “more business-related assignments” because these “realistic classes” will help to align the STEM curriculum to future industry needs. The stakeholders also pointed out that hands-on learning opportunities through internships and apprenticeships can more effectively obtain the desired results required from STEM education. This is supported by Social Constructivism since individuals need to interact for new knowledge to be formed (Williams 2017). The government school leaders also perceived STEM education to drive creativity among the students, making them capable of competing in the knowledge-driven markets and developing the necessary skills. Related to the EARTH theory, Mandrup and Jensen (2017) highlight that STEM education can benefit from the Triple Helix components through learning experiences focusing on entrepreneurship and real-world innovation. Cai and Liu (2020) also note that a knowledge-based society functions through the dynamic interactions between government, university, industry that promotes innovation, entrepreneurship and economic growth. Technology application is a key skill in a knowledge-based society. Karmokar and Shekar (2018) mention how the Triple Helix model can nurture students' entrepreneurial skills by including activities that require students to apply technology in various contexts to create prototypes. Eltanahy, Forawi and Mansour (2020) also stated that the students’ knowledge through the use of technology can be improved through the incorporation of entrepreneurship in the STEM curriculum. Similarly, the stakeholders stress the importance of incorporating technology into the STEM curriculum. According to a government stakeholder “the world has become increasingly dependent on technology” and an industry participant suggested that “this requires more updated technology to be incorporated into the STEM curriculum.” A university professor detailed that STEM should touch on relevant fields such as “micro fabrication, robotics, artificial intelligence and biomedicine”. As the participants mentioned, the Triple Helix components can help to prepare students for the needs of the future workforce and promote economic growth. Kaleva, Pursiainen, Hakola, Rusanen and Muukkonen (2019) stated that the schools implementing STEM education nurtures 21st century skills development among students. According to Etzkowitz and Leydesdorff (1998), the collaborative relationship between the three Triple Helix actors begins a creative process that can enhance education. The Triple Helix components can work towards improving STEM education to prepare students with 21st century skills so that they can thrive in a knowledge-based economy and meet the UAE Vision 2030.

The Triple Helix components can also benefit STEM careers by increasing awareness. One university professor mentioned, “as an active reader and researcher, I can help to promote STEM careers. By increasing student interest with my research background, I can highlight the links between STEM research and development and the students' classes”. This makes what students learn in the STEM classroom more relevant by linking it to real-life situations. A government teacher also mentioned that “schools and universities need to collaborate to know what is the new vision for STEM education”. A university leader pointed out that “our university is accepting school trips to promote what we offer as a department, but not what we need for the future,” indicating that more communication is needed to align STEM education with future industry needs. The Triple Helix components can create a coherent understanding and awareness of the existing and necessary links between STEM education and STEM careers.

The Triple Helix components can also increase student motivation to pursue STEM careers. Stakeholders noted that new systems are needed to support STEM students. A government teacher suggested assigning “stages to the STEM program” that enables “the student to rise to a higher stage according to his/her progress". An industry stakeholder mentioned that "there are benefits to a tracking system. Creating a student database is important because establishing a tracking system to follow the success of talented students until they reach their future careers can be very encouraging for the students." A government teacher further stressed the need for a grade-based system that awards students and makes "the program more important for both students and parents". It was also mentioned that "many parents and students are complaining that working on STEM projects takes a long time. This effort is usually used in other subjects which have grades". The participants encourage that tracking will lead to increasing the number of students pursuing STEM careers.

The collaboration and communication between the Triple Helix components can foster innovative development by increasing interaction between institutions and providing new learning opportunities for students (Etzkowitz 2003; 2008). Enriching STEM learning experiences can continue to motivate students to follow a STEM career path. An industry leader highlighted that collaboration could result in "more student competitions, more student incentives and more rewards". One government participant also said, "students received great encouragement and praise for the excellence of the projects" and institutions recognized the "possibility of benefiting from them (students) in the future" as well as providing benefits for their STEM career goals. According to SCCT, self-efficacy is a key element in career selection (Hammoud et al. 2019; Lent et al. 2017; Musso et.al 2019; Dorph et al. 2018). Self-efficacy can play a key role in positive youth development and Hackett (2002) stresses that high self-efficacy in a certain activity increases the likelihood of the person becoming more interested in it and more likely to pursue it. Supporting STEM learning experiences through the Triple Helix components can help to increase the students' self-efficacy in STEM and increase their likelihood of pursuing a STEM career path.

One theme that was repeatedly emphasized by the stakeholders was the important role played by the use of technology to benefit STEM education and STEM careers. Regarding the STEM curriculum, one participant mentioned that "STEM encourages students to use technology and to innovate and find solutions to our problems". To improve students' technological skills, one teacher stressed that "regular coordination with industry is also needed so that students can have practice with solving real world problems". Another participant highlighted that "this requires more updated technology to be incorporated into the STEM curriculum." For STEM education, technology is being used to improve students' skills and increase collaboration between schools and the Triple Helix components to make STEM learning relevant. Ardianti et al. (2020) indicate the positive benefits of using technology in STEM learning as it improves students' critical thinking skills and helps them during the learning process. According to the participants, technology can also be used to improve the communication between stakeholder groups. For instance, related to the STEM curriculum, stronger communication channels can develop more opportunities for students to take STEM online classes and to find STEM learning support. Like one stakeholder emphasized, this can support their learning in school and open the door to extracurricular STEM learning outside of regular school hours such as during the weekends and summer break. A teacher remarked that more practice will increase student confidence in STEM subjects. Regarding STEM careers, one stakeholder observed that "learning to use technology can also help students to adapt to future industries with research-based needs". Additionally, a teacher said, "It prepares the students for more challenging situations and readiness in understanding the technology-based learning of other subjects. Students will be ready for the future with research skills." Increased STEM learning activities that utilize technology will help students succeed by preparing them with the practical skills needed for future STEM industry needs. Petersen et al. (2018) recommend that technology is needed to equip students with the 21st century skills needed to help them succeed. GMIS (2019) also suggests that challenging technology-based learning activities will help students to advance in their future careers (GMIS 2019). Technology can also increase STEM awareness. A university participant observed that “more resources are needed to train students on how to use technology since they are trying to interest younger students into STEM education and careers. Another participant underscored the need to “increase the students' awareness of STEM careers. More communication will give students more access to STEM career information.” Technology is an important tool that can be used to engage younger learners and motivate older students to pursue STEM careers. Petersen et al. (2018) specify that STEM programs can give more career guidance by providing students with more access to information regarding STEM careers.

5.2 Conclusions

The Vision 2030 of the United Arab Emirates embarks on the creation of a knowledge driven and innovation-based economy. It is necessary to equip the students with the necessary skills to enable them to tackle the challenges of keeping up with the pace of technological advancements, deal with the economic uncertainty and survive the rigorous competition. The current government of the country is emphasizing the significance of STEM education as a major driver of the knowledge-based economy. The current study aimed to explore the perceptions of the stakeholders from the Triple Helix clusters regarding the implementation of formal and informal STEM education programs in the United Arab Emirates, STEM careers and the connection of the Triple Helix model to STEM education and STEM careers. The current study has employed a mixed methods approach and used both quantitative and qualitative instruments of data collection to address the research questions. The results showed that the Triple Helix can benefit both STEM education and STEM careers.

The current government of the country is emphasizing the significance of STEM education as a major driver of the knowledge-based economy. For the improvement of the current educational system, this study sought the opinions and perceptions of the stakeholders (students, leaders, teachers and parents) regarding the effective implementation of formal and informal STEM education programs. By using the Triple Helix Model, the participant opinions from government, university and industry were collected. Stakeholders highlighted that the quality could be improved through curriculum and instruction. Technology integration, simplification of subjects and professional development were highlighted as factors to enhance STEM education. Additionally, developing 21st century skills and student motivation were also mentioned. The stakeholders recognized the potential of strong communication channels between the Triple Helix clusters to improve STEM education. For instance, stronger ties with outside institutions can increase funding to improve instructional resources, align curriculum to industry requirements and provide practical professional training courses and workshops for instructors. Additionally, providing student support and guidance can help to improve student performance in STEM programs. Overall, the stakeholders communicated the various ways in which the Triple Helix model can close the gaps in STEM education.

The UAE is invested in developing a knowledge-based economy for economic growth. By increasing the volume of students pursuing careers in STEM fields, a well-trained workforce can innovate through technological advancement to attain economic prosperity. The stakeholders highlighted increasing the awareness of STEM education since information related to STEM careers is lacking. Additionally, the rigorous curriculum is discouraging STEM participants, so more incentives are needed. Lastly, an increased communication with external Triple Helix institutions was emphasized to ensure that formal and informal STEM programs evolve accordingly to meet the changing needs of the industry. The stakeholders perceived the Triple Helix components to benefit STEM careers. Through collaboration between the Triple Helix clusters, social media channels can communicate announcements and promote interaction. Students can have access to information regarding the basic requirements for STEM careers as well as available job options. In this way, communication is improving the program and the students' attitudes and motivation for STEM careers. To help with the heavy workload of the STEM curriculum, the Triple Helix can increase motivation by supporting student projects, which can attract students for STEM careers in the future. Also, STEM integration across the different disciplines needs the support of the Triple Helix Clusters. Creating learning experiences with real-world applications for students can be improved through the involvement of external institutions.

5.3 Research Implications

The sequential mixed-methods research has yielded significant findings that contribute to UAE's research regarding formal and informal STEM education programs, future STEM careers and the Triple Helix. The study produced implications for policy and future research as well as practical implications. The main implication of this study is to take the benefit of the Triple Helix collaboration and components to develop the formal and informal STEM education programs and increase the future STEM workforce to achieve the UAE's Vision 2030. The implication of the study will benefit the three clusters (government, university and industry).

5.3.1 Implications for Policymakers

The Triple Helix model has shown to be an important component throughout the COVID-19 pandemic as the government, industry and university are all collaborating for the benefit of humanity. They are working together to find solutions to overcome the economic and social problems that have resulted. With the government providing funding, the universities are researching to create the best medicines and industry is producing the medicine to be distributed to the whole world. In this research, the Triple Helix model played a new role by enhancing formal and informal STEM education programs and future STEM careers. Therefore, the research results are unique and provide innovative ideas that will benefit the UAE policymaker. For the effective adoption and implementation of the formal and informal STEM education programs, this study offers the following implications for the policymakers:

1. The Triple Helix relationships can be used to improve the STEM education policies for the creation of a knowledge-based economy and a driving force for the attainment of the UAE's Vision of 2030. For instance, professional development in government schools can incorporate the university and industry clusters so that STEM learning can be aligned with a real-world context to include practical and hands-on activities. Policymakers should facilitate professional development to incorporate the Triple Helix clusters.

2. With the collaboration between the Triple Helix clusters, a policy for effective monitoring systems to keep track of the STEM students can be developed. Creating a system that tracks STEM students can nurture STEM interests and promote STEM careers, which is in line with the Vision 2030.

3. Policies can be created for the Triple Helix clusters to collaborate to help promote the 21st century skills being taught in STEM education by expanding both formal

and informal learning activities. New policies can be designed to contribute to any area of enrichment, such as research and equipment like labs and technology.

4. The Ministry of Education can collaborate with the Triple Helix clusters to organize the programs for teacher development and training. Such programs can help in training the teachers and equipping them with the skills and technological competencies essential to adopt the STEM system.

5. Policymakers can set clear norms and procedures for collaboration and communication between the Triple Helix actors so that objectives and goals can be achieved easily.

5.3.2 Implications for the Field

Developing educational action research in schools also has positive benefits and should be prioritized. By conducting action research, the perspectives of STEM stakeholders are taken into consideration when making educational improvements related to STEM education. By supporting research in schools, leaders can empower teachers and students to lead the change in STEM education by piloting new ideas.

More awareness regarding the importance of STEM subjects is needed. Students are avoiding taking math as a major due to reasons such as a lack of interest in the subject and the lack of career opportunities associated with it. The Triple Helix clusters need to create awareness campaigns for stakeholders to strengthen the connections between STEM subjects and STEM careers for students to increase their interest in the field. Relatedly, students are unaware of their own strengths and weaknesses, leaving them unsure of what career path to follow. More career guidance is needed to expose students to STEM careers. The Triple Helix clusters can collaborate to design academic and social opportunities for STEM learning to increase student interest. These opportunities develop student self-efficacy in STEM skills which can increase motivation in STEM careers. By collaborating with the Ministry of Education, universities and industries can more readily provide student internships. Participating in these internship programs can motivate students to pursue STEM majors and STEM careers by building self-efficacy and excite students to venture into innovation. This helps to nurture students to become lifelong learners in STEM.

Regarding curriculum, technology was highlighted as a key skill. In order to successfully teach students the 21st century skills, the Triple Helix components can establish a relevant STEM curriculum to ensure that students are learning the most useful and in-demand skills. Professional development is also needed to support student learning. It is beneficial to include universities to take part in the professional development programs in cycle 2 and cycle 3 schools to develop the skills of school staff members to support student learning. The Ministry of Education can encourage the collaboration between industries and schools to promote hands-on activities in the formal and informal STEM learning environments so that cycle 2 and cycle 3 students will have more resources and experience more effective programs that can spark an interest in STEM careers. Due to the COVID pandemic, professional development can be adapted onto an e-learning channel so that the Triple Helix clusters can continue to benefit from each other by sharing best practices from all clusters.

5.4 Future Research Recommendations

For the future researchers who aim to study the benefits of the implementation of formal and informal STEM education programs in the United Arab Emirates, some of the recommendations are:

1. Since the study focuses on increasing the students' interest in STEM careers, it is recommended to have qualitative research on the students' perceptions and attitude in the classrooms towards STEM education.

2. Conduct study in both the public as well as the private sector schools to examine the difference between the two sectors and gain a better understanding of the factors that facilitate and impede the implementation of formal and informal STEM education programs.

3. By conducting a longitudinal study, the future researchers can conduct the comparative analysis. This could be helpful in tracking the changes in the quality of implementing formal and informal STEM education programs over the time and examine the changes in the perceptions of the students, teachers, parents and educational leaders over the time.

4. By using a quasi-experimental approach for STEM e-learning, the future researchers can improve STEM education programs to foster independent learners.

5. Conduct individual research between each Triple Helix component and formal and informal STEM education programs and STEM careers to see how the Triple Helix model can benefit both.

6. Investigating the impact of motivation and self-efficacy on the students' pursuit of STEM careers.

5.5 Limitations of the Study

The present research study has some limitations that leaves room for additional inquiries. These limitations are related to the difficulty of getting accessibility from the participants. One limitation of the study is the lack of a specific STEM education program.

Universities offer majors in the STEM subjects separately, as well as interdisciplinary projects. However, they do not offer STEM as a single major. This made it difficult to collect data from the university cluster, and as a result, the number of university stakeholder responses were low.

Additionally, there was a lack of STEM awareness in the Triple Helix clusters. Accordingly, the researcher included the phrase "STEM related program" in the questionnaire to emphasize the relevance of the study to the stakeholder. Other limitations that the researcher faced were the university teachers and leaders declined to take part in the sample, data collection was slow due to a lack of procedure, difficulties in finding the educational institutions that implement STEM education programs and demographic data needed for the study was not publicized.

General restrictions also made it difficult to maintain clear lines of communications, making data collection slow. For instance, the researcher was banned from interviewing students. Participants in the industry cluster were also difficult to contact since there is no official archive listing their contact information and the researcher used the institutions already having established partnerships with schools. It was also challenging to determine the number of industries supporting STEM education because this information is not being mentioned. Also, the COVID-19 presented its own obstacles. For instance, the researcher could no longer visit schools to collect data and interview participants. Industries were also closed during the pandemic.

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APPENDICES

APPENDIX 1: DOCUMENT ANALYSIS

Document Title Type of document Source and author Topic	Themes related to Formal and Informal STEM Education Programs	Themes Related to STEM Careers	Themes Related to the Triple Helix, STEM Education Programs and STEM Careers
Science, Technology & Innovation Policy in the United Arab Emirates Federal Policy paper UAE Government (2015) STEM Skills	Focus on strong STEM skills development in all school years to achieve excellent education outcomes Attract and retain the best STEM minds Need of a STEM culture that encourages and rewards Incorporate technology in STEM education	21st century skills are critical More focus on sustainability and the environment Emphasis on the responsibility of the individual to others	Integrating science, business and technology (inputs and investments from different sectors) Creating a culture of innovation among individuals, firms, and the public sector
STEM Education Policy Statement 2017-2026 (Dublin: Department of Education and Skills) Policy Document Bruton, T. (2017) PPP in Education/ Curriculum Development	Update curricula by reducing bureaucracy Incorporate the use of information technology in STEM classrooms Instructional materials develop critical thinking and problem-solving skills	Knowledge between experts from the private sector to government agencies needs to be transferred Training and developing employees on the management and operation of projects	Public-Private Partnerships (PPPs) in education maximize the potential for increasing equitable access to schooling PPPs improve education outcomes Creating a national body that is able to develop and revise the national curriculum (include

			input of external actors) PPPs can result in research investments
Challenges in STEM Learning in Australian Schools Literature and Policy Review Timms et al. (2018) STEM Learning, Communication between university and industry and motivation	Enhancing the quality of student learning in STEM by raising expectations Engagement, participation and ability in STEM classes needs to be increased Promote student development of innovative solutions	Increasing students' and stakeholders' STEM awareness	Building connections between schools and industries facilitates effective partnerships
Charting a Course for Success: America's Strategy for STEM Education Policy Document Committee on STEM Education (2018) STEM careers, Professional Development, 21st Century Skills, Universities and Innovation	Develop flexible and dynamic learning spaces for students to develop identities and interests in science (student-centric model of education) Teachers must participate in professional development. Students' skills should be expanded outside education and into the workplace with training on 'soft skills' (i.e., time management, collaboration skills, etc.)	Educating parents on the importance of encouragement of STEM aspirations Industries develop young employees by creating clear career plans and opportunities Effective, qualified, and committed student advisors can provide career support and guidance Students should be expected to complete internships, internships, or participate in research	Joint projects between local universities and industry needed (i.e., research grants) Incentives given to university faculty members who develop relationships with outside organizations School leaders should promote parental engagement

		Students' technological skills need to be able adapt to the changing dynamics of the industry Gender impacts the intention to pursue STEM careers	
What can Career & Technical Education and STEM Practitioners in the Gulf Region Learn from Practitioners in the United States? Fall 2016 ASEE Mid-Atlantic Regional Conference Paper Williams, J. (2016) STEM curriculum and STEM careers	Quality of instruction is a priority Curricula needs to incorporate project-based and student-centered learning	Students need to be prepared for postsecondary success	Stronger alignment between school and work can be achieved by partnerships between local universities and industries

APPENDIX 2: STEM GOVERNMENTAL SCHOOLS

STEM Governmental Schools Names المدارس المشاركة في دراسة تعليم العلوم والتكنولوجيا والهندسة والرياضيات في مدارس الإمارات الحكومية			
N	**Emirate**	**Gender**	**School name**
1	Sharjah	Male	AL KHALIDEIAH BOYS' SCHOOL FOR BASIC/C2 & SECONDARY EDUCATION
2	Sharjah	Female	Al Badia SECONDARY EDUCATION
3	Sharjah	Male	ABDULLA BIN AL- ZUBAIR SECONDARY BOYS' SCHOOL
4	Sharjah	Male	AL-MAHMOUD BOYS' SCHOOL FOR SECONDARY EDUCATION

5	Sharjah	Male	DHAID SECONDARY SCHOOL FOR BOYS
6	Sharjah	Female	Al -Heera Girls' School for Secondary Education C3
7	Sharjah	Female	ALREFA SECONDARY SCHOOL FOR GIRLS
8	Sharjah	MIX	AL QALAA ELEMENTARY AND SECONDARY SCHOOL FOR GIRL
9	Al Fujairah	Male	SAIF IBN HAMAD AL-SHARQI PRELIMINARY & SECONDARY BOYS SCHOOL
10	Al Fujairah	Male	ANAS IBN AL-NADAR PRELIMINARY & SECONDARY BOYS SCHOOL
11	Al Fujairah	Male	HAMAD BIN ABDULLAH AL-SHARQI SECONDARY BOYS SCHOOL
12	Al Fujairah	Male	MOHAMMED BIN HAMAD AL-SHARQI SECONDARY BOYS SCHOOL
13	Al Fujairah	Female	MERBAH SECONDARY GIRLS SCHOOL
14	Al Fujairah	Female	Al- Maarifah- 2 Girls' School for Basic & Secondar
15	Al Fujairah	MIX	AL-ITQAN PRELIMINARY & SECONDARY GIRLS SCHOOL
16	Abu Dhabi	Male	AL HOSSON SECONDARY EDUCATION
17	Abu Dhabi	Female	UMM AL ARAB C2 & SECONDARY EDUCATION
18	Abu Dhabi	Female	AMRA BINT ABDEL RAHMAN C2 & SECONDARY EDUCATION
19	Abu Dhabi	Female	BAYAH C2 & SECONDARY EDUCATION
20	Umm Al Quwain	Female	FALAJ-AL-MUALLA GIRLS' SCHOOL FOR BASIC AND SECONDARY EDUCATION
21	Umm Al Quwain	Male	HATEM AL-TA'EE BOYS' SCHOOL FOR BASIC AND SECONDARY EDUCATION
22	Umm Al Quwain	MIX	KHAWLAH BINT HAKEEM GIRLS' SCHOOL FOR BASIC AND SECONDARY
23	Dubai	Female	SUKAINA BINT ALHUSSEIN GIRLS' SCHOOL FOR SECONDARY EDUCATION

24	Dubai	Female	ASMA'A BINT AL-NO'AMAN GIRLS' SCHOOL FOR SECONDARY EDUCATION
25	Dubai	Female	Al Rashidya SCHOOL FOR BASIC SECONDARY EDUCATION
26	Dubai	Male	ALSAFA BOYS' SCHOOL FOR SECONDARY EDUCATION
27	Dubai	Male	MOHAMMED BIN RASHID AL MAKTOUM MODEL SCHOOL
28	Dubai	MIX	Al - Qeyam Boys' School for Secondary Education C3
29	Dubai	Female	AL-RAYAH GIRL S SCHOOL FOR SECONDARY EDUCATION
30	Dubai	Female	AL-RAYAH GIRL S SCHOOL FOR SECONDARY EDUCATION
31	Dubai	Female	AL SALAM GIRLS ' SCHOOL FOR BASIC SECONDARY EDUCATION
32	Ras Al Khaimah	Female	AL-NAJAH GIRLS' SCHOOL FOR BASIC AND SECONDARY EDUCATION
33	Ras Al Khaimah	Male-	High School FOR SECONDARY EDUCATION
34	Ras Al Khaimah	Female	AL-JEER GIRLS' SCHOOL FOR SECONDARY EDUCATION
35	Ras Al Khaimah	Female	AL-SABAHEYA GIRLS' SCHOOL FOR SECONDARY EDUCATION
36	Ras Al Khaimah	Female	Al - Maereid Girls' School for Secondary Education
37	Ras Al Khaimah	Male	AL-RAMS BOYS' SCHOOL FOR SECONDARY EDUCATION
38	Ras Al Khaimah	Male	AL-GHEEL BOYS' SCHOOL FOR SECONDARY EDUCATIO
39	Ras Al Khaimah	Male	SHA'AM SCHOOL FOR BASIC EDUCATION AND SECONDARY SCHOOL BOYS
40	Ajman	Male	AL-RASHEDIA BOYS' SCHOOL FOR SECONDARY EDUCATION
41	Ajman	Male	ABU SAEED AL-KHODREY BOYS' SCHOOL FOR BASIC AND SECONDARY

42	Ajman	Male	IBN HAZM BOYS' SCHOOL FOR BASIC AND SECONDARY EDUCATION
43	Ajman	Female	ASMA'A BINT OMAIS GIRLS' SCHOOL FOR SECONDARY EDUCATION
44	Ajman	Female	Al - Zawra'a Girls' School for Secondary Education
45	Ajman	Female	AJMAN GIRLS' SCHOOL FOR SECONDARY EDUCATION
46	Ajman	MIX	AL-NOAIMEYAH GIRLS' SCHOOL FOR BASIC AND SECONDARY

APPENDIX 3: QUESTIONNAIRES FOR ALL STAKEHOLDERS

Government School Student STEM Questionnaire

Dear Students,

This questionnaire aims to gain your perceptions about the influences on science-based (Science, Technology, Engineering and Math – [STEM]) career choices. Your participation is voluntary and the information you provide will be used for research purposes only.

<u>Section A: Demographic Information</u>

Please fill in the following information about yourself by checking one box.

1-Gender

☐Female ☐Male

2-Type of STEM (Science, Technology, Engineering) program you joined

☐ In-school STEM program ☐ After school STEM program

3-Grade Level (optional)

☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ others

4-Intention of attending university

☐Yes ☐ No ☐ Undecided

5-Do you want to pursue STEM (Science, Technology, Engineering and Math) careers in these fields in the future?

☐Science ☐Technology ☐Engineering ☐Math
☐None of the above

<u>Section B: STEM Perceptions</u>

The items in this section of the survey relate to student perceptions of the STEM (Science-Technology, Engineering and Math) program. To what extent are these statements applicable to the STEM program you joined?

For each statement, please (✓) the box for your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Preparing students to meet industry needs					
					1- It is clear why my current STEM program is important.
					2- My current STEM program will help to prepare me for my future job.
					3- The STEM subjects (Science, Technology, Engineering and Maths) can be learned effectively through practical activities.
					4- I have the ability to easily solve problems by creating solutions in my current STEM projects.
					5- The STEM program is easier to learn with my current STEM instructor/teacher.
					6- I like the current STEM program I am a part of.
Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	

Skills Development					
					7- My current STEM program requires effective speaking and writing skills.
					8- I have a clear role in my team during my current STEM activities.
					9- I use modern technology in my current STEM activities.
					10- I learn skills to solve problems effectively in my current STEM program.
					11- I learn how to break down large projects in a step-by-step process in my current STEM program.
					12- My current STEM program can solve problems related to the world effectively.

Section C: STEM Career Perceptions

The statements in this section of the survey relate to the level of future STEM Career Perceptions and Career Interests. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) program you joined?

For each sentence, please check (✓) the box for your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	

Better outcomes and incentives					
					1- My current STEM subjects contain helpful information on STEM careers.
					2- Most STEM careers are in high demand.
					3- Most STEM careers have high paying jobs.
					4- Most STEM careers require hard work.
Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Attracting and retaining the best minds					
					5- The goals of the STEM program I joined are clear.
					6- My current STEM program is emotionally rewarding.
					7- My achievements in my current STEM program are recognized by the community.
					8- It is important that awards are given to students with the most improved grades in my current STEM program.

Future vision					
					9- A STEM major will help me to fulfil the vision of the UAE becoming an innovation driven economy.
					10- Studying STEM will help me get into the major that I want easily.
					11- By studying STEM, I will be able to get the job I want easily.

<u>Section D: Triple Helix component</u>

The items in this section of the survey relate to the level of coordination, collaboration, and communication between decision makers, industries, and universities. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) program you joined?

For each sentence, please check (✓) the box for your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Coordination and communication of universities, industry, and STEM Program					
					1- After-school university workshops in my current STEM program are arranged regularly.
					2- My current STEM program always gives me the chance to meet STEM role models (famous people).

					3- My current STEM program gives me the chance to work with related companies and institutions.
					4- My current STEM program provides some trips to companies that are involved in STEM.
					5- My current STEM program helps me to choose my future job.
					6- My current STEM program always offers internships.

Thank you for your participation

Government School Leader / STEM Questionnaire

Dear Leaders

This questionnaire aims to gain your perception on how the STEM program influences the students' on science-based (Science, Technology, Engineering and Maths – [STEM]) career choices. Your participation is voluntary and the information you provide will be used for research purposes only.

Section A: Demographic Information

Please provide the following information and check one option that is applicable to you.

1-Type of STEM (Science, Technology, Engineering and Maths) program you are responsible for

☐ In-school STEM program ☐ After school STEM program

2- What STEM grade level(s) are you responsible for? (optional)

☐ 6 ☐ 7 ☐ 8 ☐ 9
☐ I am not working in school

Section B: STEM Perceptions

The items in this section of the survey relate to the STEM Leaders' perception on the science based (Science, Technology, Engineering and Maths) STEM program. To what extent are the following statements applicable to your organisation?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Preparing students to meet industry needs					
					1- The current STEM program is important for students.

					2- I am satisfied with the current STEM program objectives to prepare students for future needs effectively.
					3- Students always show hands-on practices in the current STEM program.
					4- Problem solving always takes an important part of the current STEM program.
					5- Professional development for leaders is effective in the current STEM program.

-

Section C: STEM Career Perception

The statements in this section of the survey relate to STEM Career Perception and Career Interests. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) program you joined?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Better outcomes and incentives					
					1- The current STEM subjects connect to student career choices.
					2- Future careers mostly demand STEM graduates.

					3- Most STEM careers are well paid.
					4- Student performances in school greatly reflect potential STEM career success.
Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Attracting and retaining the best minds					
					5- The goals of the current STEM program are introduced clearly.
					6- Students find the current STEM program to be emotionally rewarding.
					7- High performing students in science-based subjects are mostly attracted to the current STEM program.
					8- Students with the most improved grades in the current STEM classes are given incentives.
Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Future vision					
					9- A STEM major will most likely help students to fulfil the vision of

					the UAE becoming an innovation driven economy.
					10- STEM skills will allow students to enter the major of their choice easily.
					11- Students with STEM skills will have greater chances for their career choice.

-

<u>Section D: Triple Helix component</u>

The statements in this section of the survey relate to the level of coordination, collaboration, and communication between decision makers, industries, and universities. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) program you are responsible for?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Coordination and communication among universities, industries and STEM programs					
					1- The current STEM program closely communicates with universities to provide STEM workshops.
					2- The current STEM program gives students regular opportunities to meet STEM role models.

					3- The current STEM program offers students projects to work on with other companies and organisations.
					4- The current STEM program regularly organizes trips to companies involved in STEM.
					5- The current STEM program gives clear guidance on future careers.
					6- The current STEM program always offers internships.
					7- School leaders communicate regularly with industries to improve the current STEM program.
					8- There is a regular collaboration between schools, universities, and industry to improve the current STEM program.
Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Perceptions on STEM Strategy					
					9- The current STEM program encourages students to pursue STEM careers successfully.
					10- The current STEM professional development is implemented effectively for leaders.

					11- The current STEM program mainly focuses on 21st century skills.
					12- Feedback from leaders is always taken into consideration when developing the current STEM program.
					13- Sufficient allocations are always made for STEM education resources into the current STEM program.
					14- The current STEM program mostly meets the demands of industries.

If you are interested in participating in an interview regarding this research, please write your email below:

Government School Teacher STEM Questionnaire

Dear Teachers,

This questionnaire aims to gain your perception on how the STEM program influences the students on science-based (Science, Technology, Engineering and Maths – [STEM]) career choices. Your participation is voluntary and the information you provide will be used for research purposes only.

Section A: Demographic Information

Please provide the following information and check one option that is applicable to you.

1- Type of STEM program STEM (Science, Technology, Engineering and Maths) program you are responsible for

☐ After school STEM program ☐ In-school STEM program

2- What STEM grade level(s) are you responsible for? (optional)

☐ I am not working in a school ☐ 9 ☐ 8 ☐ 7 ☐ 6

Section B: STEM perceptions

The items in this section of the survey relate to the STEM teachers' perception on the science based (Science, Technology, Engineering and Maths) STEM program. To what extent are the following statements applicable to your organization?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Preparing students to meet industry needs					

					1- The current STEM program is important for students.
					2- The current STEM program objectives are well prepared to meet students' future needs.
					3- Students always show hands-on practices in the current STEM program.
					4- Problem solving always takes an important part in the current STEM program.
					5- Professional development effectively prepare teachers to teach the current STEM program.

Section C: STEM Career Perception

The statements in this section of survey relate to STEM Career Perception and Career Interests. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) program you are responsible for?

For each statement, please check the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/don't know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Better outcomes and incentives					
					1- The current STEM subjects are linked to student career choices.

					2- Future careers mostly demand STEM graduates.
					3- Most STEM careers are well paid.
					4- Student performances in school greatly reflect potential STEM career success.
Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Attracting and retaining the best minds					
					5- The goals of the current STEM program are introduced clearly.
					6- Students find STEM careers to be emotionally rewarding.
					7- High performing students in science-based subjects are mostly attracted to the current STEM program.
					8- Students with the most improved grades in the current STEM classes are given incentives.
Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**

(1)	(2)	(3)	(4)	(5)	
Future vision					
					9- A STEM major will students to fulfil the vision of the UAE becoming an innovation driven economy.
					10- STEM skills will allow students to enter the major of their choice easily.
					11- Students with STEM skills will have greater chances for their career choice.

<u>Section D: Triple Helix component</u>

The statements in this section of the survey relate to the level of coordination, collaboration, and communication between decision makers, industries, and universities. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) program you are responsible for?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Coordination and communication among universities, industries and STEM programs					
					1- The current STEM program closely communicates with universities to provide STEM workshops.

					2- The current STEM program gives students regular opportunities to meet STEM role models.
					3- The current STEM program offers students projects to work on with other companies and organisations.
					4- The current STEM program regularly organizes trips to companies involved in STE.
					5- The current STEM program gives clear guidance on future careers.
					6- The current STEM program always offers internships.
					7- Teachers are given the opportunity to effectively coordinate with universities to improve the current STEM program.
					8- There is a regular collaboration between schools, universities, and industry to improve the current STEM program.
Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Perceptions on STEM strategy					

					9- The current STEM program encourages students to pursue STEM careers successfully.
					10- The current STEM professional development is implemented effectively for teachers.
					11- The current STEM program mainly focuses on 21st century skills.
					12- Feedback from teachers is always taken into consideration when developing the STEM program.
					13- Sufficient allocations are always made for STEM education resources into the STEM program.
					14- The current STEM program mostly meets the demands of industries.

If you are interested in participating in an interview regarding this research, please write your email below:

Participant Email

……………………………………………………………………………………………..…………

For further information, please feel free to email: fm2school@yahoo.com

Government School Parents STEM Questionnaire

Dear Parents,

This questionnaire aims to solicit your perceptions on your child's science-based (Science, Technology, Engineering and Maths – [STEM]) career choices. Your participation is voluntary and the information you provide will be used for research purposes only.

Section A: Demographic Information

Please provide the following information and check one option that is applicable to you.

1-Type of STEM program (Science, Technology, Engineering and Maths) your child joined

☐ In-school STEM program ☐ After school STEM program

2-Your (son/ daughter) in the STEM program is in grade

☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐others

Section B: STEM perception

The items in this section of the survey relate to parents' perception on STEM program that their child is enrolled in. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) program your child joined?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Preparing students to meet industry needs					
					1- Joining the current STEM program is

					important for my (son/daughter).
					2- The current STEM program sufficiently prepares my (son/daughter) for future career needs.
					3- My (son/daughter) is passionate about the current STEM program.
					4- My (son/daughter) takes great interest in the current STEM program from their STEM teacher(s).

-

Section C: STEM career perception

The statements in this section of survey relate to STEM Career Perception and Career Interests. To what extent are these statements applicable to your child who joined the STEM (Science, Technology, Engineering and Maths) program from a parent's perspective?

For each statement, please check the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/don't know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Better outcomes and incentives					
					1- The STEM subjects in my (son/daughters)'s current STEM program is not linked to career choices.

					2- Future careers mostly demand STEM graduates.
					3- Most STEM careers are well paid.
					4- Most STEM careers need hard work
					5- I will encourage my (son/daughter) to study STEM subjects in university.
					6- My (son/daughter) has the freedom of choice when choosing a career.
Future vision					
					7- A STEM major will help my (son/daughter) to fulfill the vision o the UAE becoming an innovation-driven society.
					8- STEM skills will allow my (son/daughter) to enter the major of their choice easily.
					9- STEM skills will allow my (son/daughter) to get the job they want easily.

<u>Section D: Triple Helix component</u>

The items in this section of the survey relate to the level of coordination, collaboration, and communication between decision makers, industries, and universities. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) program your child joined?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Statements**
(1)	(2)	(3)	(4)	(5)	
Coordination and communication among universities, industries and STEM programs					
					1- Universities offer after-school STEM workshops regularly for my (son/daughter) in their current STEM program.
					2- The current STEM program provides my (son/daughter) many opportunities to meet STEM role models.
					3- The current STEM program offers many projects for my (son/daughter) to work on with other companies and institutions.
					4- The current STEM program regularly organizes trips to companies involved in STEM.
					5- The current STEM program gives clear

					guidance on STEM future careers.
					6- The current STEM program always offers internships.

University Leader/Educator STEM Questionnaire

Dear Leader/Educator,

This Survey aims to gain your perception on how the STEM program influences the students' on science-based (Science, Technology, Engineering and Maths – [STEM]) career choices.

Note: STEM program is based on integrating four specific disciplines (science, technology, engineering and mathematics) in an interdisciplinary and applied approach. Rather than teach the disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications. It can be applied and demonstrated through students' projects or innovations while solving real life problems.

Your participation is voluntary and the information you provide will be used for research purposes only.

<u>Section A: Demographic Information</u>

Please provide the following information and check one option that is applicable to you.

1.1- Which Emirate is your university located in?

☐Abu Dhabi
☐Dubai
☐Sharjah
☐Ajman
☐Ras Al Khaimah
☐Umm Al Quwain
☐Fujairah

1.2-Type of STEM (Science, Technology, Engineering and Maths) program you are responsible for (For example: In- in compass STEM program, after Summer STEM program, or others)

1.3- What STEM level(s) are you responsible for? (optional) For example: cycle 2, freshman, sophomore, undergraduate, graduate, etc.

<u>2.Section B: STEM Perceptions</u>

The items in this section of the survey relate to the STEM Leaders'/Educators' perception on the program related to STEM (Science, Technology, Engineering and Maths). To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) related program you are responsible for?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Preparing students to meet industry needs					
2.1- The current program (related to STEM) is important for students.					
2.2- I am satisfied with the current curriculum (related to STEM) to prepare students for future industrial needs.					
2.3- Students always show hands-on practices in the current program (related to STEM).					
2.4- Problem solving strategies always take an important part of the current program (STEM).					
2.5- Professional development for leaders/educators is an effective part of the current program (related to STEM).					

<u>3.Section C: STEM Career Perception</u>

The statements in this section of the survey relate to STEM Career Perception and Career Interests. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) related program you joined?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disag ree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Better outcomes and incentives					
3.1- The current STEM-related subjects connect to student career choices.					
3.2- Future careers mostly demand STEM-related graduates.					
3.3- Most careers related to STEM are well paid.					
3.4- Student performances in school greatly reflect potential STEM-related career success.					

Statements	Strongly agree	Agree	Neutral	Dis agree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
4.Attracting and retaining the best minds					
4.1- The goals of the current program (related to STEM) are introduced early.					
4.2- Students find the current program (related to STEM) to be emotionally rewarding.					
4.3- High performing students in science-based subjects are mostly attracted to the current program (related to STEM).					
4.4- Students with the most improved grades in the current STEM-related classes are given incentives.					

Statements	Strongly agree	Agree	Neutral	Dis agree	Strongly disagree

	(5)	(4)	(3)	(2)	(1)
5.Future vision					
5.1 A STEM-related major will most likely help students to fulfill the vision of the UAE becoming an innovation driven economy.					
5.2 STEM-related skills will allow students to enter the major of their choice easily.					
5.3 Students with STEM-related skills will have greater chances for their career choice.					

6.Section D: Triple Helix component

The statements in this section of the survey relate to the level of coordination, collaboration, and communication between decision makers, industries, and universities. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) related program you are responsible for?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Coordination and communication among universities, industries and STEM programs					
6.1 The current STEM-related program closely communicates with universities to provide STEM workshops.					
6.2- The current STEM-related program gives students regular opportunities to meet STEM role models.					
6.3 The current STEM-related program offers students volunteer projects to work on with other companies and organisations.					

6.4 The current STEM-related program regularly organizes trips to companies involved in STEM.					
6.5 The current STEM-related program gives clear guidance on future careers.					
6.6 The current STEM-related program always offers internships.					
6.7- The institution communicates regularly with industries to improve the current STEM-related program.					
6.8- There is a regular collaboration between schools, universities, and industry to improve the current STEM-related program.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
7.Perceptions on STEM Strategy					
7.1 The current STEM-related program encourages students to pursue STEM careers successfully.					
7.2 The current STEM-related professional development is implemented effectively for leaders/educators.					
7.3 The current STEM-related program mainly focuses on 21st century skills.					
7.4 Feedback from leaders/educators is always taken into consideration when developing the current STEM-related program.					
7.5 Sufficient allocations are always made for STEM-related education resources into the current STEM-related program.					

7.6 The current STEM-related program mostly meets the demands of industries.					

If you are interested in participating in an interview regarding this research, please write your email below:

Participant Email

……………………………………………………………………………………….…………

For further information, please feel free to email: 20170365@student.buid.ac.ae.

University Student STEM Questionnaire

Dear Students,

This questionnaire aims to gain your perceptions about the influences on science-based (Science, Technology, Engineering, and Maths – [STEM]) career choices.

Note: STEM program is based on integrating four specific disciplines (science, technology, engineering and mathematics) in an interdisciplinary and applied approach. Rather than teach the disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications. It can be applied and demonstrated through students' projects or innovations while solving real life problems.

Your participation is voluntary and the information you provide will be used for research purposes only.

1.Section A: Demographic Information

Please fill in the following information about yourself by checking one box.

1.1Which Emirate is your university located in?

☐Abu Dhabi
☐Dubai
☐Sharjah
☐Ajman
☐Ras Al Khaimah
☐Umm Al Quwain
☐Fujairah

1.2- Gender

☐Male ☐Female

1.3-Type of program (related to STEM-Science, Technology, Engineering and Maths) you joined (For example: In compass STEM program, Summer STEM program, or others)

1.4-Education Level For example: undergraduate, graduate, Student, etc.
………………………...
1.5-Do you want to pursue a STEM (Science, Technology, Engineering and Maths) career in the field you are in?
………………………..

2.Section B: STEM Perceptions

The items in this section of the survey relate to student perceptions of the STEM (Science, Technology, Engineering, and Maths) program. To what extent are these statements applicable to the STEM-related program you joined?

For each statement, please check (✓) the box for your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Preparing students to meet industry needs					
2.1- It is clear why my current program (which is related to STEM) is important.					
2.2- My current curriculum (which is related to STEM) will prepare me for future industrial needs.					
2.3- The STEM subjects (Science, Technology, Engineering, and Maths) can be learned effectively through practical activities.					
2.4- I have the ability to easily solve problems by using strategies used in STEM (Science, Technology, Engineering, and Maths) subjects.					
2.5- My program (which is related to STEM) is easier to learn with my current instructor/teacher.					
2.6- I like the current program (which is related to STEM) that I am a part of.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Skills Development					

3.1- My current program (which is related to STEM) requires effective speaking and writing skills.					
3.2- I learn my subject (which is related to STEM) by collaborating with other students.					
3.3- I use modern technology in my current STEM-related program.					
3.4- I learn skills to solve problems effectively in my current program (which is related to STEM).					
3.5- I learn how to break down large projects in a step-by-step process in my current program (which is related to STEM).					
3.6 - My current program (which is related to STEM) requires solving problems related to the world effectively.					

4.Section C: STEM Career Perceptions

The statements in this section of the survey relate to the level of future STEM Career Perceptions and Career Interests. To what extent are these statements applicable to the STEM (Science, Technology, Engineering, and Maths) related program you joined?

For each statement, please check (✓) the box for your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Better outcomes and incentives					
4.1- My current STEM-related program contains helpful information on STEM careers.					
4.2- STEM-related careers are in high demand.					
4.3- STEM-related careers have high paying jobs.					

4.4- STEM-related careers require hard work.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Attracting and retaining the best minds					
5.1- The goals of my program (which is related to STEM) are clear.					
5.2- My current program (which is related to STEM) is emotionally rewarding.					
5.3- My achievements in my current program (which is related to STEM) are recognized by the community.					
5.4- It is important that awards are given to students who show improvement in my current STEM program.					
Future vision					
6.1- A major (related to STEM) will help me to fulfill the vision of the UAE becoming an innovation driven economy.					
6.2- Studying a STEM-related subject will help me get into the major that I want easily.					
6.3- By studying a STEM-related subject, I will be able to get the job I want easily.					

7. Section D: Triple Helix component

The items in this section of the survey relate to the level of coordination, collaboration, and communication between decision makers, industries, and universities. To what extent are these statements applicable to the STEM (Science, Technology, Engineering, and Maths) related program you joined?

For each statement, please check (✓) the box for your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
7.Coordination and communication of universities, industry, and STEM Program					
7.1- After-school university workshops (related to STEM) in my current program are arranged regularly.					
7.2- My current program (related to STEM) always gives me the chance to meet STEM role models (famous people).					
7.3- My current program (related to STEM) gives me the chance to volunteer with companies and institutions related to STEM.					
7.4- My current program (related to STEM) provides some trips to companies that are involved in STEM.					
7.5- My current program (related to STEM) helps me to choose my future job.					
7.6- My current program (related to STEM) always offers internships.					

Thank you for your participation

Institutions Students STEM Questionnaire

Dear Students,

This questionnaire aims to gain your perceptions about the influences on science-based (Science, Technology, Engineering, and Maths – [STEM]) career choices.

Note: STEM program is based on integrating four specific disciplines (science, technology, engineering and mathematics) in an interdisciplinary and applied approach. Rather than teach the disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications. It can be applied and demonstrated through students' projects or innovations while solving real life problems.

Your participation is voluntary and the information you provide will be used for research purposes only.

1.Section A: Demographic Information

Please fill in the following information about yourself by checking one box.

1.1Which Emirate is your STEM school located in?

☐Abu Dhabi
☐Dubai
☐Sharjah
☐Ajman
☐Ras Al Khaimah
☐Umm Al Quwain
☐Fujairah

1.2- Gender

☐Male ☐Female

1.3--Type of STEM (Science, Technology, Engineering and Maths) program you joined (For example: In compass STEM program, Summer STEM program, or others)

1.4-Education Level (optional)For example: cycle2,cycle3 undergraduate, graduate, Student, etc……

1.5-Do you want to pursue a STEM (Science, Technology, Engineering and Maths) related career? Mention pleases ………

2.Section B: STEM Perceptions

The items in this section of the survey relate to student perceptions of the STEM (Science, Technology, Engineering, and Maths) program. To what extent are these statements applicable to the STEM-related program you joined?

For each statement, please check (✓) the box for your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Preparing students to meet industry needs					
2.1- It is clear why my current program (which is related to STEM) is important.					
2.2- My current program (which is related to STEM) will prepare me for future industrial needs.					
2.3- The subjects related to STEM (Science, Technology, Engineering, and Maths) can be learned effectively through practical activities.					
2.4- I have the ability to easily solve problems by using strategies used in STEM (Science, Technology, Engineering, and Maths) related subjects.					
2.5- My program (which is related to STEM) is easier to learn with my current instructor/teacher.					
2.6- I like the current program (which is related to STEM) that I am a part of.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Skills Development					

3.1- My current program (which is related to STEM) requires effective speaking and writing skills.					
3.2- I learn STEM subjects (Science, Technology, Engineering, and Maths) in the STEM-related program by collaborating with other students.					
3.3- I use modern technology in my current STEM-related program.					
3.4 - I learn skills to solve problems effectively in my current program (which is related to STEM).					
3.5-I learn how to break down large projects in a step-by-step process in my current program (which is related to STEM).					
3.6- My current program (which is related to STEM) requires solving problems related to the world effectively.					

4.Section C: STEM Career Perceptions

The statements in this section of the survey relate to the level of future STEM Career Perceptions and Career Interests. To what extent are these statements applicable to the STEM (Science, Technology, Engineering, and Maths) program you joined?

For each statement, please check (✓) the box for your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Better outcomes and incentives					
4.1- My current STEM-related program contains helpful information on STEM careers.					
4.2- STEM-related careers are in high demand.					

4.3- STEM-related careers have high paying jobs.					
4.4- STEM-related careers require hard work.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Attracting and retaining the best minds					
5.1- The goals of my program (which is related to STEM) are clear.					
5.2- My current program (which is related to STEM) is emotionally rewarding.					
5.3- My achievements in my current program (which is related to STEM) are recognized by the community.					
5.4- It is important that awards are given to students who show improvement in my current STEM program.					
Future vision					
6.1- A major (related to STEM) will help me to fulfill the vision of the UAE becoming an innovation driven economy.					
6.2- Studying a STEM-related subject will help me get into the major that I want easily.					
6.3- By studying a STEM-related subject, I will be able to get the job I want easily.					

7. Section D: Triple Helix component

The items in this section of the survey relate to the level of coordination, collaboration, and communication between decision makers, industries, and universities. To what extent are these statements applicable to the STEM (Science, Technology, Engineering, and Maths) program you joined?

For each statement, please check (✓) the box for your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagr ee	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
7.Coordination and communication of universities, industry, and STEM-related program					
7.1- After-school university workshops in my current STEM program are arranged regularly.					
7.2- My current STEM program always gives me the chance to meet STEM role models (famous people).					
7.3- My current STEM program gives me the chance to volunteer with companies and institutions related to STEM.					
7.4- My current STEM program provides some trips to companies that are involved in STEM.					
7.5- My current STEM program helps me to choose my future job.					
7.6- My current STEM program always offers internships.					

Thank you for your participation

Leader/Educator STEM Questionnaire (Institutions)

Dear institutional leaders/instructors:

This Survey aims to gain your perception on how the STEM program influences students on science-based (Science, Technology, Engineering and Maths – [STEM]) career choices. Your participation is voluntary and the information you provide will be used for research purposes only.

<u>Section A: Demographic Information</u>

Please provide the following information and check one option that is applicable to you.

1.1- Which Emirate is your STEM school located in?

☐Abu Dhabi
☐Dubai
☐Sharjah
☐Ajman
☐Ras Al Khaimah
☐Umm Al Quwain
☐Fujairah

1.2-Type of STEM (Science, Technology, Engineering and Maths) related program you are responsible for (For example: In- school STEM program, after school STEM program, or others)

1.3- What grade level(s) are you responsible for? (optional)For example: cycle 2, freshman, sophomore, undergraduate, graduate, etc.

<u>2.Section B: STEM Perceptions</u>

The items in this section of the survey relate to the institutional leader's/instructor's perception on the science-based STEM (Science, Technology, Engineering, and Maths) related program. To what extent are the following statements applicable to your institution?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

The items in this section of the survey relate to the STEM Leaders'/Educators' perception on the science based (Science, Technology, Engineering and Maths) STEM program. To what extent are the following statements applicable to your organization?

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Preparing students to meet industry needs					
2.1- The current STEM-related program is important for students.					
2.2- The current STEM-related program is able to prepare students to meet future industrial needs.					
2.3- Students always show hands-on practices in the current STEM-related program.					
2.4- Problem-solving strategies always take an important part in the current STEM-related program.					
2.5- Professional development for teachers is an effective part of the current STEM-related program.					

3.Section C: STEM Career Perception

The statements in this section of the survey relate to STEM Career Perception and Career Interests. To what extent are these statements applicable to the STEM (Science, Technology, Engineering and Maths) program you joined?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don’t Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Better outcomes and incentives					
3.1- The current STEM-related programs are linked to student career choices.					

3.2- STEM-related careers are in high demand.					
3.3- Most STEM-related careers are well paid.					
3.4- Student performances in school greatly reflect potential STEM-related career success.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
4.Attracting and retaining the best minds					
4.1- The goals of the current STEM-related program(s) are introduced early.					
4.2- Students find STEM careers to be emotionally rewarding.					
4.3- High performing students in science-based subjects are mostly attracted to the current STEM-related program(s).					
4.4- Students in the current STEM-related classes are given incentives.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
5.Future vision					
5.1 - A STEM-related major will help me to fulfill the vision of the UAE becoming an innovation driven economy.					
5.2- STEM-related skills will allow students to enter the major of their choice easily.					
5.3- Students with STEM-related skills will have greater chances for their career choice.					

6.Section D: Triple Helix component

The statements in this section of the survey relate to the level of coordination, collaboration, and communication between decision makers, industries, and universities. To what extent are these statements applicable to the STEM (Science, Technology, Engineering, and Maths) program you are responsible for?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
Coordination and communication among universities , industries and STEM programs					
6.1- The current STEM-related program closely communicates with other schools to provide STEM workshops.					
6.2- The current STEM-related program gives students regular opportunities to meet STEM role models.					
6.3- The current STEM-related program offers students projects to work on with other companies and organisations.					
6.4- The current STEM-related program regularly organizes trips to companies involved in STEM.					
6.5- The current STEM-related program gives clear guidance on future careers.					
6.6- The current STEM-related program always offers internships.					
6.7- The institution communicates regularly with universities to improve the current STEM-related program.					

6.8- There is a regular collaboration between schools, universities, and industry to improve the current STEM-related program.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
7.Perceptions on STEM Strategy					
7.1- The current STEM-related program encourages students to pursue STEM careers successfully.					
7.2- STEM-related professional development for industry leaders is implemented effectively.					
7.3- The current STEM-related program mainly focuses on 21st century skills.					
7.4- Feedback from leaders is always taken into consideration when developing the current STEM-related program.					
7.5- Sufficient allocations are always made for STEM-related education resources into the current STEM-related program.					
7.6- The current STEM-related program mostly meets the demands of industries.					

If you are interested in participating in an interview regarding this research, please write your email below:

Participant Email

……………………………………………………………………………………………..………

For further information, please feel free to email: 20170365@student.buid.ac.ae.

Industry Professional STEM Questionnaire

Dear Industry Professional,

This Survey aims to gain your perception on how the STEM program influences the students on science-based (Science, Technology, Engineering and Math – [STEM]) career choices. Your participation is voluntary and the information you provide will be used for research purposes only.

1.Section A: Demographic Information

Please provide the following information and check one option that is applicable to you.

1.1- Which Emirate is your STEM program located in?

☐Abu Dhabi
☐Dubai
☐Sharjah
☐Ajman
☐Ras Al Khaimah
☐Umm Al Quwain
☐Fujairah

1.2-Type of STEM (Science, Technology, Engineering and Math) program you are responsible for (For example: In- school STEM program, after school STEM program, or others)

1.3- What STEM grade level(s) are you responsible for? (optional)For example: cycle 2, freshman, sophomore, undergraduate, graduate, etc.

2.Section B: STEM perceptions

The items in this section of the survey relate to the STEM teachers' perception on the science based (Science, Technology, Engineering, and Math) STEM program. To what extent are the following statements applicable to your organization?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
2. Preparing students to meet industry needs					
2.1- The current STEM program is important for students.					
2.2- The current STEM curriculum is able to prepare students to meet future industrial needs.					
2.3- Students always show hands-on practices in the current STEM program.					
2.4- Problem-solving strategies always take an important part in the current STEM program.					
2.5- Professional development for teachers is an effective part of the current STEM program.					

3. Section C: STEM Career Perception

The statements in this section of survey relate to STEM Career Perception and Career Interests. To what extent are these statements applicable to the STEM (Science, Technology, Engineering, and Math) program you are responsible for?

For each statement, please check the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/don't know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
3. Better outcomes and incentives					
3.1- The current STEM subjects are linked to student career choices.					
3.2- STEM careers are in high demand.					

3.3- Most STEM careers are well paid.					
3.4- Student performances in school greatly reflect potential STEM career success.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
4.Attracting and retaining the best minds					
4.1- The goals of the current STEM program are introduced early.					
4.2- Students find STEM careers to be emotionally rewarding.					
4.3- High performing students in science-based subjects are mostly attracted to the current STEM program.					
4.4 Students with the most improved grades in the current STEM classes are given incentives.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
5.Future vision					
5.1- A STEM major will help me to fulfill the vision of the UAE becoming an innovation driven economy.					
5.2- STEM skills will allow students to enter the major of their choice easily.					
5.3- Students with STEM skills will have greater chances for their career choice.					

6.Section D: Triple Helix component

The statements in this section of the survey relate to the level of coordination, collaboration, and communication between decision makers, industries, and universities. To what extent are these statements applicable to the STEM (Science, Technology, Engineering, and Math) program you are responsible for?

For each statement, please put a check mark (✓) in the box that corresponds to your choice of either Strongly Agree (5), Agree (4), Neutral/Don't Know (3), Disagree (2), or Strongly Disagree (1).

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	(5)	(4)	(3)	(2)	(1)
6.Coordination and communication among universities, industries and STEM programs					
6.1- The current STEM program closely communicates with other schools to provide STEM workshops.					
6.2- The current STEM program gives students regular opportunities to meet STEM role models.					
6.3- The current STEM program offers students projects to work on with other companies and organisations.					
6.4- The current STEM program regularly organizes trips to companies involved in STEM.					
6.5- The current STEM program gives clear guidance on future careers.					
6.6- The current STEM program always offers internships.					
6.7- The institution communicates regularly with universities to improve the current STEM program.					
6.8- There is a regular collaboration between schools, universities, and industry to improve the current STEM program.					
Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree

	(5)	(4)	(3)	(2)	(1)
7.Perceptions on STEM strategy					
7.1- The current STEM program encourages students to pursue STEM careers successfully.					
7.2- STEM professional development for industry leaders is implemented effectively.					
7.3- The current STEM program mainly focuses on 21st century skills.					
7.4- Feedback from leaders is always taken into consideration when developing the current STEM program.					
7.5- Sufficient allocations are always made for STEM education resources into the current STEM program.					
7.6- The current STEM program mostly meets the demands of industries.					

If you are interested in participating in an interview regarding this research, please write your email below:

Participant Email

……………………………………………………………………………………………..……….

For further information, please feel free to email: fm2school@yahoo.com.

APPENDIX 4: TRANSLATED STREAM QUESTIONNAIRE

استبيان ستيم STEM (العلوم - تكنولوجيا - الهندسة - والرياضيات) للطلاب في المدارس الحكومية

السادة مدراء المدارس الحلقة الثانية والثالثة المحترمين

تقوم الباحثة / فاطمة حسين من الجامعة البريطانية في دبي بإجراء استبانة بعنوان " "التطلع الى دراسة ستيم STEM في الحلقة الثانية والثالثة في دولة الإمارات العربية المتحدة ومستقبله المهني من منظور مكون هيلكس الثلاثي" حيث تم تصميم الاستبيان للاطلاع على آراء الطلبة في المدرسة الإماراتية بالحلقة الثانية والثالثة في جميع امارات الدولة في برنامج ستيم STEM الخاص بالمواد (العلوم - التكنولوجيا - الهندسة - والرياضيات) لمعرفة العوامل المؤثرة في خيارات المهنية في المستقبل. كما أن مشاركتهم في الاستبيان تطوعية، وتستخدم للأغراض البحثية فقط. مع مراعاة الدقة عند الاجابة لما لآرائكم أهمية بالغة في تحليل نتائج الدراسة.

1.القسم الأول: المعلومات الديموغرافية

الرجاء تكملة المعلومات الشخصية التالية من خلال اختيار الاجابة المناسبة:

1.1الإمارة

☐ أبوظبي ☐ دبي ☐ الشارقة ☐ عجمان ☐ رأس الخيمة ☐ ام القيوين ☐ الفجيرة

1.2. الجنس

☐ أنثى ☐ ذكر

1.3. الصف الدراسي

☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ أخرى

1.4 الرغبة في الالتحاق بالجامعة

☐ نعم ☐ لا ☐ لم أقرر بعد

1.5. هل ترغب في متابعة دراستك بنظام) ستيم (STEM)هذه المجالات؟

☐ العلوم ☐ التقنية ☐ الهندسة ☐ الرياضيات ☐ لا شيء مما ورد أعلاه

2.القسم الثاني: استيعاب برنامج ستيم STEM (العلوم - التكنولوجيا - الهندسة - والرياضيات)

تتعلق البنود المضمنة في هذا القسم من الاستبيان استيعاب الطلاب لنظام ستيم STEM.

إلى أي مدى ترى أن هذه العبارات تنطبق على برنامج ستيم STEM الذي التحقت به؟

الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة

	(5)	(4)	(3)	(2)	(1)
أولا: إعداد الطلاب بغرض استيفاء المقتضيات الصناعية:					
2.1. أنا على علم ودراية ببرنامج ستيم STEM الحالي (العلوم - تكنولوجيا -القراءة - الهندسة - الفن - والرياضيات)					
2.2. إنني على قناعة بأن منهاج نظام ستيم STEM سيقوم بتأهيلي لاستيفاء الاحتياجات الصناعية في المستقبل.					
2.3. أتعلم في برنامج ستيم STEM الحالي من خلال الكثير من التطبيقات والانشطة العملية.					
2.4. لدي القدرة على حل المشكلات بسهولة في المشاريع باستخدام استراتيجيات برنامج ستيم STEM الحالي.					
2.5. إنني على قناعة بقدرة أستاذي الحالي على تدريس منهاج ستيم STEM					
2.6. انا أحب دراسة منهاج ستيم STEM.					
الإفــــــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
3. ثانيا: تطوير المهارات:					
3.1 أعتقد بأن معظم العمل ضمن نشاطات برنامج ستيم STEM الحالي يتطلب مهارات في المخاطبة والكتابة.					
3.2. أتعلم ضمن نشاطات ستيم STEM الحالي أن أعمل ضمن التعاون مع مجموعة من الطلبة.					
3.3. تستخدم أجهزة التكنولوجيا والأدوات التقنية الأخرى في نشاطات ستيم STEM الحالي.					

3.4. في برنامج ستيم STEM الحالي أتعلم مهارة حل المشكلات بفعالية.					
3.5. أتعلم كيفية تقسيم العمل بالمشاريع الكبيرة خطوة بخطوة وعلى مراحل في برنامج ستيم STEM الحالي.					
3.6. برنامج ستيم STEM الحالي يعمل على حل المشاكل الحقيقية في العالم بكفاءة.					

4.القسم الثالث: استيعاب المستقبل المهني لنظام ستيم STEM (العلوم - تكنولوجيا - الهندسة - والرياضيات)

تتعلق الإفادات في هذا القسم بمدى الإدراك والاهتمام بالمستقبل المهني لنظام ستيم STEM (العلوم - تكنولوجيا - الهندسة - والرياضيات)، وإلى أي مدى تنطبق هذه الإفادات على برنامج ستيم STEM الذي التحقت به؟

الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
أولا: أفضل النتائج والمحفزات					
4.1 برنامج ستيم STEM الذي التحقت به يشتمل على معلومات مفيدة عن مستقبل ستيم STEM المهني.					
4.2. هناك طلب عن مجال ستيم STEM المهني					
4.3. العائد المادي كبير بالنسبة للوظائف في مجال ستيم STEM					
4.4 المهن في نظام ستيم STEM تتطلب جهد كبير ومثابرة في العمل.					
الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
5. ثانيا: استقطاب أفضل العقول والمحافظة عليها					

5.1. أهداف برنامج ستيم STEM الحالي واضحة.					
5.2. المستقبل المهني لنظام ستيم STEM الحالي يعتبر واعداً ومؤثراً.					
5.3. إنجازاتي في برنامج ستيم STEM الحالي تحظى بالتقدير من المجتمع.					
5.4. من المهم تقديم جوائز للطلاب المتفوقين في برنامج ستيم STEM الحالي.					
6.ثالثا: الرؤية المستقبلية					
6.1. الدراسة بنظام ستيم STEM ستمكنني من تحقيق أهداف دولة الإمارات العربية لمستقبل أفضل (لتصبح صاحبة اقتصاد يرتكز على الابتكار).					
6.2. الدراسة بنظام استريم STEMالحالي ستمكنني من الحصول على التخصص الذي أرغب فيه في المستقبل.					
6.3. الدراسة بنظام ستيم STEM الحالي ستمكنني من الحصول على الوظيفة التي أريدها.					

7. القسم الرابع: مكون هيليكس الثلاثي

تتعلق بنود هذا القسم بمستوى التنسيق، والتعاون بين برنامج ستيم STEM وأصحاب القرار، المؤسسات الصناعية، والجامعات. إلى أي مدى ترى أن هذه العبارات تنطبق على برنامج ا ستيم STEM(العلوم -التكنولوجيا - الهندسة - والرياضيات) الذي التحقت به؟

الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
7. اولا: التنسيق والتعاون بين الجامعات والمؤسسات الصناعية، منهجية منظومة ستيم STEM:					
7.1 يتم توفير ورش عمل خاصة ببرنامج ستيم STEM الحالي للطلبة من قبل الجامعات					
7.2. البرنامج يوفر لي العديد من الفرص لمقابله على قادة وشخصيات مشهورة في مجال ستيم STEM.					
7.3. برنامج ستيم STEMالحالي يوفر لي فرصة العمل كمتطوع في شركات ومؤسسات في مجال ستيم STEM.					

7.4. هناك العديد من الرحلات المنظمة للشركات التي يتعلق عملها بنظام ستيم STEM.					
7.5. برنامج ستيم STEM الحالي يساعدني في اختيار وظيفتي في المستقبل.					
7.6. العمل في المؤسسات الخارجية والشركات والذي يهدف التدريب هو أفضل الأساليب في تعلم ستيم STEM.					

شكراً على مشاركتك في الاستبيان

<u>استبيان (ستيم STEM) العلوم - التكنولوجيا - الهندسة - الرياضيات) للقادة في المدارس الحكومية</u>

السادة مدراء النطاق / مدراء المدارس الحلقة الثانية والثالثة المحترمين

تقوم الباحثة / فاطمة حسين من الجامعة البريطانية في دبي بإجراء استبانة بعنوان " "التطلع الى دراسة ستيم STEM في الحلقة الثانية والثالثة في دولة الإمارات العربية المتحدة ومستقبله المهني من منظور مكون هيلكس الثلاثي" حيث تم تصميم الاستبيان للاطلاع على آراء مدراء النطاق ومدراء المدارس في المدرسة الإماراتية بالحلقة الثانية والثالثة في جميع إمارات الدولة في برنامج (ستيم STEM) والخاص بالمواد (<u>العلوم - التكنولوجيا - الهندسة - الرياضيات</u>) لمعرفة العوامل المؤثرة في خيارات المهنية في المستقبل. كما أن مشاركتهم في الاستبيان تطوعية، وتستخدم للأغراض البحثية فقط. مع مراعاة الدقة عند الإجابة. . مع مراعاة الدقة عند الإجابة لما لآرائكم أهمية بالغة في تحليل نتائج الدراسة.

<u>1.القسم الأول: المعلومات الديموغرافية</u>

الرجاء تكملة المعلومات الشخصية التالية من خلال الضغط على الخيار المناسب:

1.1. الإمارة

1.2. ☐ أبوظبي ☐ دبي ☐ الشارقه ☐ عجمان ☐ رأس الخيمه

☐ ام القيوين ☐ الفجيرة

2.1. تشتمل الفصول الدراسية في المدرسة التي تقع تحت مسؤوليتك والمطبقة لبرنامج (ستيم STEM)

6 ☐ 7 ☐ 8 ☐ 9 ☐ ☐لا أعمل في المدرسة

<u>2.القسم الثاني: استيعاب برنامج (ستيم STEM) العلوم - التكنولوجيا - الهندسة - الرياضيات</u>

تتعلق البنود المضمنة في هذا القسم من الاستبيان رأي القادة بنظام (ستيم STEM).

إلى أي مدى ترى أن هذه العبارات تنطبق على برنامج (ستيم STEM) في مؤسستك؟

الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
إعداد الطلاب بغرض استيفاء المقتضيات الصناعية:					
2.1. برامج (ستيم STEM) الحالي ذات أهمية بالنسبة للطلاب.					

2.2. منهاج (ستيم STEM) قادر على إعداد الطلاب للمتطلبات الصناعية في المستقبل.					
2.3 الطلاب يتعلمون باستخدام التطبيقات العملية في برنامج (ستيم STEM).					
2.4 استراتيجيات حل المشكلات أمر مطبق في برنامج (ستيم STEM) الحالي.					
2.5 نظام (ستيم STEM) يوفر برامج تطوير مهني فعال للقادة.					

3. القسم الثالث: المستقبل المهني لنظام ستيم STEM(العلوم - التكنولوجيا - الهندسة - الرياضيات)

تتعلق الإفادات في هذا القسم بالمستقبل المهني للطلبة الملتحقين ببرنامج (ستيم STEM) (العلوم - التكنولوجيا - الهندسة - الرياضيات). إلى أي مدى تنطبق هذه الإفادات على برنامج (ستيم STEM) الذي التحقت به؟

الرجاء وضع علامة (√) في الدائرة التي تتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
أفضل النتائج والمحفزات					
3.1 مواد (ستيم STEM) لها صلة بالمهن والوظائف المستقبلية.					
3.2 هناك طلب على مجال (ستيم STEM) المهني.					
3.3 العائد المادي كبير بالنسبة للوظائف في مجال (ستيم STEM).					
3.4 أداء الطلاب العالي في المواد الدراسية يعكس إمكانية نجاحهم في مستقبلهم المهني في مجال (ستيم STEM).					
الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
استقطاب أفضل العقول والمحافظة عليها					

4.1هناك مبادرات لتوضيح أهداف برنامج (ستيم STEM) في بداية البرنامج.					
4.2. المستقبل المهني لنظام (ستيم STEM) يعتبر واعداً ومؤثراً.					
4.3. الطلبة الحاصلين على أداء عالي في المواد العلمية هم أكثر الطلبة المنجذبين الى برنامج (ستيم STEM) الحالي.					
4.4. هناك أهمية كبيرة لتقديم جوائز للطلاب المتفوقين في برامج (ستيم STEM) الحالي.					
الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
الرؤية المستقبلية					
5.1 التخصص في أحد مجالات ((ستيم STEM) سيمكن الطلاب من تحقيق رؤية الإمارات في أن يصبح اقتصادها مرتكزاً على الابتكار و التجديد.					
5.2اكتساب مهارات (ستيم STEM) سيتمكن الطلاب من التخصص في المجال الذي يرغبون فيه مستقبلا.					
5.3 اكتساب مهارات (ستيم STEM) سيتمكن الطلاب من تحديد مستقبلهم المهني.					

6. القسم الرابع: مكون هيليكس الثلاثي

تتعلق بنود هذا القسم بمستوى التنسيق، والتعاون، والتواصل بين صناع القرار، وبين المؤسسات الصناعية، والجامعات وبرنامج (ستيم STEM). إلى أي مدى ترى أن هذه العبارات تنطبق على برنامج (ستيم STEM) الذي التحقت به؟

الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
التنسيق والتواصل بين الجامعات والمؤسسات الصناعية، وبرامج (ستيم STEM)					

6.1 يتم توفير ورش عمل خاصة ب(ستيم STEM) للطلبة من قبل الجامعات					
6.2 برنامج (ستيم STEM) الحالي يتيح العديد من الفرص باللقاء مع قادة وشخصيات مشهورة في مجال (ستيم STEM) .					
6.3 برنامج (ستيم STEM) الحالي يوفر للطالب الفرص للعمل كمتطوع في مشاريع مع شركات ومؤسسات أخرى.					
6.4 يتم تنظيم زيارات ورحلات دورية للشركات والمؤسسات التي تحتوي على نظام (ستيم STEM).					
6.5 نظام (ستيم STEM) يوفر برنامج للترشيد حول المستقبل المهني للطلبة.					
6.6 العمل في المؤسسات الخارجية والشركات بهدف التدريب هو من أفضل الأساليب في تعلم (ستيم STEM).					
6.7 هناك فرص متاحة للقادة للتنسيق والتواصل مع المؤسسات الصناعية والجامعات بغرض تطوير برامج (ستيم STEM) الحالي.					
6.8 هناك تعاون منظم بين المدراس، والجامعات والمؤسسات الصناعية لتطوير برنامج (ستيم STEM) الحالي.					
الإفـــــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
مدى الاستيعاب منهجية (ستيم STEM)					
7.1 برنامج (ستيم STEM) تشجع وتساعد الطلاب على المواصلة في المجالات المهنية المتعلقة بنظام (ستيم STEM).					
7.2 دورات التطوير المهني المقدمة للقادة في مجال (ستيم STEM) فعالة.					
7.3برنامج (ستيم STEM) الحالي يركز بفعالية على مهارات القرن					
7.4 التغذية الراجعة المقدمة من قبل القادة لها اعتبار في تطوير نظام (ستيم STEM) الحالي.					

7.5 تم رصد مخصصات كافية من أجل توفير المصادر للتعليم بنظام (ستيم STEM) الحالي في المدارس.					
7.6. برنامج (ستيم STEM) الحالي في الغالب يلبي يستوفي المتطلبات الصناعية.					

شكراً على مشاركتك في الاستبيان

استبيان ستيم STEM (العلوم - التكنولوجيا - الهندسة - والرياضيات) للمعلمين فى المدارس الحكومية

السادة مدراء المدارس الحلقة الثانية والثالثة المحترمين

تقوم الباحثة / فاطمة حسين من الجامعة البريطانية في دبي بإجراء استبانة بعنوان " "التطلع الى دراسة ستيم STEM في الحلقة الثانية والثالثة في دولة الإمارات العربية المتحدة ومستقبله المهني من منظور مكون هيلكس الثلاثي" حيث تم تصميم الاستبيان للاطلاع على آراء معلمي العلوم والرياضيات وتقنية المعلومات في المدرسة الإماراتية بالحلقة الثانية والثالثة في جميع إمارات الدولة في برنامج ستيم STEM الخاص بالمواد (العلوم - التكنولوجيا - الهندسة - والرياضيات) لمعرفة العوامل المؤثرة في خيارات المهنية في المستقبل. كما أن مشاركتهم في الاستبيان تطوعية، وتستخدم للأغراض البحثية فقط. مع مراعاة الدقة عند الإجابة لما لآرائكم أهمية بالغة في تحليل نتائج الدراسة

1.القسم الأول: المعلومات الديموغرافية

الرجاء تكملة المعلومات الشخصية التالية من خلال اختيار المناسب:

1.1. الإمارة

☐ أبوظبي ☐ دبي ☐ الشارقه ☐ عجمان ☐ راس الخيمه ☐ ام القيوين ☐ الفجيرة

1.2. نوع برنامج استريم STEM(العلوم - تكنولوجيا - الهندسة - الرياضيات) الذي تتولى مسؤوليته مطبق على المراحل الدراسية:

☐ 6 ☐ 7 ☐8 ☐ 9 ☐لا أعمل في المدرسة

2.القسم الثاني: استيعاب لبرنامج ستيم STEM

تتعلق البنود المضمنة في هذا القسم من الاستبيان راي المعلمون بنظام ستيم STEM.

إلى أي مدى ترى أن هذه العبارات تنطبق على برنامج ستيم STEM في مؤسستك؟

الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
إعداد الطلاب بغرض استيفاء المقتضيات الصناعية:					
2.1. برنامج ستيم STEM مهم بالنسبة للطلبة					
2.2. منهاج ستيم STEM قادر على إعداد الطلاب للمتطلبات الصناعية في المستقبل.					

2.3. الطلاب يستخدمون التطبيقات والانشطة العملية في برنامج ستيم STEM					
2.4 استراتيجية حل المشكلات أمر مطبق في برنامج ستيم STEM الحالي.					
2.5 نظام ستيم STEM يوفر برامج تطوير مهني فعال للمعلمين.					

3.القسم الثالث: المستقبل المهني لنظام ستيم STEM

تتعلق الإفادات في هذا القسم بالمستقبل المهني للطلبة الملتحقين ببرنامج ستيم STEM (العلوم – التكنولوجيا- - الهندسة -الرياضيات). إلى أي مدى تنطبق هذه الإفادات على برنامج ستيم STEM الذي التحقت به؟ الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
أفضل النتائج والمحفزات					
3.1. مواد ستيم STEM لها صلة بالمهن المستقبلية للطلاب.					
3.2. هناك طلب كبير على مجال ستيم STEM المهني في المستقبل.					
3.3. العائد المادي كبير بالنسبة للوظائف في مجال ستيم STEM					
3.4. أداء الطلاب العالي يعكس إمكانية نجاحهم في مستقبلهم المهني في مجال ستيم STEM					
الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
4. ثانيا: استقطاب أفضل العقول والمحافظة عليها					
4.1 هناك مبادرات لتوضيح أهداف برنامج ستريم STEM في بداية البرنامج.					
4.2 المستقبل المهني لدراسة ستيم STEM يعتبر واعدا ومؤثراً.					
4.3 الطلبة الحاصلين على أداء عالي في المواد العلمية هم الطلبة المنجذبين الى برنامج ستيم STEM					

4.4. من المهم تقديم جوائز للطلاب المتفوقين في برامج ستيم .STEM					
الإفـــــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
5. ثالثا: الرؤية المستقبلية					
5.1. التخصص في أحد مجالات ستيم STEM سيمكن الطلاب من تحقيق رؤية دولة الإمارات في أن يصبح اقتصادها مرتكزاً على الابتكار والتجديد.					
5.2 من خلال اكتساب مهارات ستيم STEM سيتمكن الطلاب من التخصص في المجال الذي يرغبون فيه.					
5.3 من خلال اكتساب مهارات ستيم STEM سيتمكن الطلاب في تحديد مستقبلهم المهني.					

6.القسم الرابع: مكون هيليكس الثلاثي

تتعلق بنود هذا القسم بمستوى التنسيق، والتعاون، والتواصل بين برنامج ستيم STEM و (صناع القرار، المؤسسات الصناعية، الجامعات). إلى أي مدى ترى أن هذه العبارات تنطبق على برنامج ستيم STEM الذي التحقت به؟

الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
أولا: التنسيق والتواصل بين الجامعات والمؤسسات الصناعية، وبرامج ستيم STEM					
6.1 يتم توفير ورش عمل خاصة ببرنامج ستيم STEM للطلبة من قبل الجامعات					
6.2 البرنامج يتيح الفرص لمقابلة المسؤولين والمشاهير في مجال ستيم STEM					
6.3. الطلاب مع برنامج ستيم STEM يجدون فرص للمشاركة في العمل كمتطوعين في مشاريع مع شركات ومؤسسات في مجال ستيم .STEM					
6.4. يتم من خلال برنامج ستيم STEM تنظيم زيارات ورحلات للشركات المختصة في مجال ستيم STEM					

6.5. نظام ستيم STEM يوفر برنامج للترشيد حول المستقبل المهني للطلبة.					
6.6. العمل من أجل التدريب في المؤسسات الخارجية والشركات هومن أفضل الأساليب في تعلم ستيم STEM					
6.7. الفرصة متاحة للمعلمين للتنسيق والتواصل مع الجامعات بغرض تطوير برنامج ستيم STEM الحالي.					
6.8. هناك تعاون دائم منسق بين المدارس والجامعات والمؤسسات الصناعية بغرض تطوير برنامج ستيم STEM الحالي.					
الإفـــــــــــــادات	أوافق بشدة	أوافق	لا أدري	لا أوافق	لا أوافق بشدة
	(5)	(4)	(3)	(2)	(1)
7. ثانيا: مدى الاستيعاب لمنهجية ستيم STEM					
7.1 برنامج (ستيم STEM) تشجع وتساعد الطلاب على المواصلة في المجالات المهنية المتعلقة بنظام (ستيم STEM).					
7.2 دورات التطوير المهني المقدمة للمعلمين في مجال (ستيم STEM) فعاله.					
7.3 برنامج ستيم STEM يركز بفعالية على مهارات القرن 21.					
7.4 التغذية الراجعة المقدمة من قبل المعلمين لها اعتبار في تطوير نظام ستيم STEM					
7.5تم رصد مخصصات كافية من أجل توفير مصادر التعليم بنظام ا ستيم STEM في المدارس.					
7.6.برنامج ستيم STEM في الغالب يلبي ويستوفي المتطلبات الصناعية في مستقبل الدولة.					

استبيان ستيم STEM (العلوم - االتكنولوجيا - الهندسة - الرياضيات) لأولياء الأمور فى المدارس الحكومية

السادة مدراء المدارس الحلقة الثانية والثالثة المحترمين
تقوم الباحثة / فاطمة حسين من الجامعة البريطانية في دبي بإجراء استبانة بعنوان " "التطلع الى دراسة ستيم STEM في الحلقة الثانية والثالثة في دولة الامارات العربية المتحدة ومستقبله المهني من منظور مكون هيلكس الثلاثي" حيث تم تصميم الإستبيان للاطلاع على **آراء أولياء الأمور** الطلبة في المدرسة الإماراتية بالحلقة الثانية والثالثة في جميع امارات الدولة في برنامج ستيم STEM والخاص بالمواد (العلوم - التكنولوجيا - الهندسة - الرياضيات) لمعرفة العوامل المؤثرة في خيارات المهنية في المستقبل. كما أن مشاركتهم في الاستبيان تطوعية ، وستستخدم للأغراض البحثية فقط . مع مراعاة الدقة عند الاجابة . مع مراعاة الدقة عند الاجابة لما لارائكم أهميه بالغة في تحليل نتائج الدراسه .

القسم الأول:1. المعلومات الديموغرافية
الرجاء تكملة المعلومات الشخصية التالية من خلال التظليل على المربع المناسب:
1.1.الامارة
☐أبوظبي ☐دبي ☐ الشارقه ☐عجمان ☐راس الخيمه ☐ام القيوين ☐فجيرة

1.2. الفصل الدراسي لأبنك / ابنتك المنضم لبرنامج ستيم STEM
☐6 ☐ 7 ☐8 ☐9 ☐غير ذلك

القسم الثاني:2. استيعاب برنامج ستيم STEM
تتعلق البنود المضمنة في هذا القسم من الاستبيان على تصورات أولياء الأمور عن برنامج ستيم STEM الذي انضم اليه ابنهم/ابنتهم إلى أي مدى ترى أن هذه العبارات تنطبق على برنامج ستيم STEM الذي التحق به ابنك/ ابنتك؟ الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، **لا** أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــــادات	أوافق بشدة (5)	أوافق (4)	لا أدري (3)	لا أوافق (2)	لا أوافق بشدة (1)
أولا: 2.تجهيز الطلاب بغرض استيفاء المقتضيات الصناعية :					
2.1. الدراسة في برامج ستيم STEM مهمة بالنسبة لإبني/ ابنتي.					
2.2. منهاج ستيم STEMالحالي قادر على إعداد إبني / ابنتي لمتطلبات المهنته في المستقبل.					
2.3. أبني / ابنتي مستمتع ببرنامج ستيم STEM الحالي.					
2.4 أنا راض عن ما يقوم به المعلم /المعلمة حالياً في تدريس منهاج ستيم STEM لإبني/ ابنتي.					

القسم الثالث: 3. المستقبل المهني لنظام ستيم STEM
تتعلق البنود في هذا القسم عن آرائكم في المستقبل المهني لبرنامج ستيم STEM (العلوم – التكنولوجيا - الهندسة - الرياضيات) . إلى أي مدى تنطبق هذه البنود على برنامج ستيم STEM الذي التحق به ابنك / ابنتك؟ الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1)

الإفـــــــــــادات	أوافق بشدة (5)	أوافق (4)	لا أدري (3)	لا أوافق (2)	لا أوافق بشدة (1)
أولا: أفضل النتائج والمحفزات					
3.1 مواد ستيم STEM لها صلة بالخيارات المهنية لإبني/ابنتي في المستقبل					
3.2. هناك طلب كبيرعلى مجال ستيم STEM المهني					
3.3. العائد المادي كبير بالنسبة للوظائف في مجال ستيم STEM.					
3.4. المستقبل المهني في مجال ستيم STEM متعب ويحتاج الى جهد كبير.					
3.5. أشجع ابني/ ابنتي على الدراسة في مجال ستيم STEM في الجامعة					
3.6. ابني / ابنتي لهم الخيار المطلق في أختيار التخصص في المستقبل الجامعي.					
4. ثانيا: الرؤية المستقبلية					
4.1. إذا درس إبني / ابنتي بنظام است ستيم STEM ،فإن ذلك سيمكن من تحقيق هدف دولة الامارات ليصبح اقتصادها مرتكزاً على الابتكار والتجديد.					
4.2. من خلال الدراسة بنظام ستيم STEM سيتمكن إبني / ابنتي من الدراسة في التخصص الذي يرغب فيه.					
4.3. من خلال الدراسة بنظام ستيم STEM سيتمكن إبني/ ابنتي من الحصول على الوظيفة التي يريدها.					

5.القسم الرابع: مكون هيليكس الثلاثي

تتعلق بنود هذا القسم بمستوى التنسيق، والتعاون، بين صناع القرار، و المؤسسات الصناعية، والجامعات في خدمة برنامج ستيم STEM ، إلى أي مدى ترى أن هذه العبارات تنطبق على برنامج ستيم STEM الذي التحق به ابنك/ ابنتك؟

الرجاء وضع علامة (√) في المربع الذي يتناسب مع اختيارك من بين ، أوافق بشدة (5) ، أوافق (4)، لا أدري (3)، لا أوافق (2)، لا أوافق بشدة (1).

الإفـــــــــــادات	أوافق بشدة (5)	أوافق (4)	لا أدري (3)	لا أوافق (2)	لا أوافق بشدة (1)
أولا: التنسيق والتواصل بين الجامعات و المؤسسات الصناعية، وبرامج ستيم STEM					

5.1. يتم توفير ورش عمل خاصة باست ستيم STEM لابني / لابنتي من قبل الجامعات

5.2. البرنامج يتيح الفرص لابني / لابنتي لمقابلة المسؤولين والمشاهير في مجال ستيم STEM.

5.3. برنامج ستيم STEM الحالي يوفر لابني / لابنتي فرص للمشاركة والعمل في مشاريع مع شركات ومؤسسات تختص بنظام ستيم STEM.

4.5. يتم من خلال برنامج ستيم STEM الحالي تنظيم زيارات ورحلات للشركات المختصة في مجال ستيم STEM.

5.5. نظام ستيم STEM الحالي يوفر لابني / لابنتي برنامج للترشيد حول المستقبل المهني للطلبة.

6.5. العمل في المؤسسات الخارجية والشركات بهدف التدريب هي من أفضل الأساليب في تعلم ستيم STEM لابني / لابنتي.

شكراً على مشاركتك في الاستبيان

APPENDIX 5: SEMI-STRUCTURED INTERVIEW WITH TEACHERS

Leaders/ Teachers Interview Protocol

Interviewee job title: …………………….

Interviewee ………………………..

First, I would like to thank you for accepting to be part of my study.

I am a doctoral student at BUiD. I am conducting this interview as part of my Doctoral Thesis study titled "Investigating Formal and Informal STEM Education Programs and STEM Career Development through the Implementation of the Triple Helix Model in the UAE". These interviews aims to gain your perceptions about STEM (Science/Technology/Engineering/Maths) and student career choices in the STEM field for the future**.**

I would like to inform you that the interview will not take more than 20 minutes. All of the responses will be recorded immediately if you allow me. Also, all of your responses will be kept confidential and not shared with anyone. Additionally, your names will not be mentioned in the study.

Please do not hesitate to ask me any questions before we start.

Q1. Why do you think STEM (Science/Technology/Engineering/Maths) education in the UAE is preparing students for future industry needs and future vision 2030?

1. لماذا تعتقد أن برنامج ستيم (العلوم والتكنولوجيا والتعليم والرياضيات) في دولة الإمارات العربية المتحدة يعد الطلاب لاحتياجات الرؤية المستقبلية 2030 ؟

Q2- How did the STEM program affect the student's perception in pursuing STEM careers? What is the (school -university- institution) doing for this purpose? explain. What kind of initiatives were given to students?

2-كيف أثر البرنامج التعليمي في العلوم والتكنولوجيا والهندسة والرياضيات (STEM)على تصور الطالب لمتابعة المهن المستقبلية والمختصة بستيم؟ ماذا تفعل (المدرسة - الجامعة - المؤسسة) لهذا الغرض؟ يشرح. ما نوع المبادرات التي أعطيت للطلاب؟

Q3- Does your institution use collaboration to serve the STEM program in the public school? Describe your collaboration and what was gained from it. What is the importance of the collaboration between school -university- institution? Explain your response.

كيف تم التعاون بين مؤسستكم والمدارس لخدمة برنامج ستيم؟ وما تم تقديمه؟ الرجاء التوضيح

Q4. What are your suggestions to improve the STEM program which can encourage students to pursue STEM careers in the future?

س 4. ما هي اقتراحاتك لتحسين برنامج STEM الذي يمكن أن يشجع الطلاب على متابعة وظائف STEM في المستقبل؟

APPENDIX 6: CONSENT FORM FOR LEADERS /TEACHERS

Dear Teachers/ Leaders,

I am a doctoral candidate at the British University in Dubai BUID. The title of my research is: Investigating Formal and Informal STEM Education Programs and STEM Career Development through the Implementation of the Triple Helix Model in the UAE.

I am conducting research to investigate the stakeholder's perceptions on the formal and informal STEM programs and their impact upon students' career choices. Moreover, I will study the relationship with the Triple Helix in Abu Dhabi Middle and High schools. You will be asked to complete a questionnaire with questions related to these topics.

As a participant in this questionnaire, you will be answering questions that are divided into in 4 sections:

Firstly, you will be asked to complete a consent form. Upon approval, you will complete the questionnaire.
1-Demographic Information 2- STEM Perception
3- STEM Career Perception 4- Triple Helix Component

Your participation in this research is voluntary. Furthermore, you are free to withdraw your consent at any time from the investigation. There will be no penalty and any information held about you will be destroyed upon withdrawal.

The information collected from this questionnaire is anonymous and confidential.

Thank you for agreeing to take part in this research. I appreciate your time and effort in answering the questionnaire.

Email: 20170365@student.buid.ac.ae.

Yours faithfully,

Fatima Yousif

Leader / Teacher Informed Consent Form

I have read the information presented to me above and I understand all the steps. Therefore, I agree to participate in this research. I have the right to withdraw at any time. I have received a copy of this form.

Leader's /Teacher's Full Name ________________________________

Signature _______________Date ________________

I certify that I have explained to the above individual the purpose of the study and the potential benefits associated with participation in this research investigation. I have answered any questions that have been raised.

Investigator's Signature ____

Date ______________________________________

If you have any questions concerning this investigation, please contact me using the following email: 20170365@student.buid.ac.ae.

Alternatively, you can contact my supervisor and director of the study: Prof. Sufian A Forawi

Email: sufian.forawi@buid.ac.ae
TEL: +97142791439

الجامعة البريطانية في دبي

The British University in Dubai

www.buid.ac.ae

Monday, 23 December 2019

To whom it may concern

This is to certify that **Ms. Fatima Husain** with Student ID number **20170365** is a registered part-time student in the **Doctor of Education** offered by **The British University in Dubai** since **September 2017.**

Ms. Husain has successfully completed her taught modules and is currently working on her thesis titled **"Transitioning of STEM Education and its Employment through the Implementation of the Triple Helix Model in Abu Dhabi Middle and High Schools"**

She needs your support in conducting surveys and interviews to complete her research.

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

Yours sincerely,

Ahmed Abu Shaaban
Senior Students Administrator

APPENDIX 7: DOCUMENT ANALYSIS PROTOCOL

Date:
Document Title:
Document Type :
Source:
Document Number/Citation:
Summary of Document:
Importance:
Relevance to research Question 1:
Key Exemplars/Quotes:
Follow Up Action Steps (If needed):