QATAR UNIVERSITY

COLLEGE OF EDUCATION

PRIMARY SCIENCE TEACHERS' PERCEPTIONS TOWARDS STEM EDUCATION IN QATAR AND CHALLENGES OF ITS IMPLEMENTATION.

BY

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ABSTRACT

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Title:_Primary Science Teachers' Perceptions towards STEM Education in Qatar and Challenges of its Implementation

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Understanding teachers' perceptions of STEM education is crucial to ensure the quality of teaching and learning provided for the students in the classrooms. This study aimed at investigating science teachers' perceptions towards STEM education in primary public schools in the State of Qatar, in terms of four domains: teachers' knowledge, STEM teaching requirements, impact on students' outcomes, and the perceived challenges of implementation. This study followed a sequential explanatory mixed-method approach. Quantitative data was collected by surveying (148) science teachers, while qualitative data was obtained using four focus groups. Results highlighted the need to increase teachers' understanding and knowledge of STEM disciplines and their approaches to integration. Furthermore, various challenges were reported, including insufficient professional development, changing teachers' beliefs, lack of an integrated curriculum and lack of time. Additionally, results indicated that there were no significant differences in teachers' perceptions with regard to gender or educational background, while there is differences in relation to teaching experience in the challenges domain. Moreover, results indicated the significant difference in teachers' perceptions related to the received STEM professional development programs and STEM teaching experience in the first three domains. Based on the results, the study recommended that there is a need to develop STEM integrated curriculum and to provide STEM professional development programs.

DEDICATION

This Thesis is dedicated to my beloved husband Hossam for his endless support,

My lovely sons Omar and Karim for their patience on my busy schedules,

My father Fayed Hassan Fathy who always believe in me,

My mother Enass Serag who is really missed.

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Chapter One: Introduction

Across the world, governments recognize teachers as the cornerstones for successful and sustainable educational development. Teachers' critical role in preparing students to be global citizens who can compete in this fast-changing world is indispensable. In this vein, there has been a growing interest recently in the fields of STEM (science, technology, engineering, and mathematics) in all over the world and in Qatar specifically (Sellami, El- Kassem, Al-Qassass & Al-Rakeb, 2017).

Over the past decade, STEM education was a global focus consideration in both developed and developing countries (El-Deghaidy& Mansour, 2015). STEM education is enthused by the demand of global workforce and the economy needs to fulfill the deficiency of STEM competent workers. Within the current competitive global marketplace, the four domains of science, technology, engineering and mathematics are crucial parts of education. This highlighted the prominence of STEM education and its impact on developing well-educated skilled work force to push their countries forwards towards economic expansion (Ahmed, 2016). Thus, STEM is the key for shifting countries and nations towards economic growth and sustainable development (Khuyen, Bien, Lin, Lin & Chang., 2020).

STEM is an acronym generated from using the initials of four main disciplines Science, Technology, Engineering, and Mathematics in order to refer to education and practices in those fields (McDonald, 2016). STEM is an interdisciplinary cohesive learning paradigm, where integration of these disciplines is the heart of STEM. Thus, STEM removes the barriers between the four fields and introduces them in an authentic context (Hom, 2014). The main goal of STEM education is to encourage school students at an early age to have an interest in STEM subjects, which will expand their opportunities in the job market, and eventually, there will be a return on investment on the overall country's economy.

In general, the term “STEM” is used while addressing school issues related to education policy and curriculum choices with an objective to improve competitiveness in the development field of science and technology. STEM improves teaching practices via remarkable alteration from direct explanation and lecturing in traditional classes to inquiry practices, problem solving and project based learning (El-Deghaidy & Mansour, 2015). Subsequently, STEM education enhances students’ capacity to become self-independent learners, critical thinkers, and support them to acquire social communication and collaboration skills to use them in solving real life problems in an increasingly technological and multifaceted international community (Ahmed, 2016).

It is worth mentioning that STEM education, which is based on an interdisciplinary pragmatic approach, vary in its level of detail from one grade to the other. Elementary schools focus on the introductory level of STEM subjects by increasing the awareness of STEM fields and related occupations. In middle school, the courses become more challenging while pursuing but with an advanced level the awareness of STEM fields and its related occupations. At high school, it focuses on the application and merging the gap between in-school education and beyond school employment opportunities (Kanadlı, 2019). Therefore, new researchers and academics are now taking further steps by introducing the concept of STEM with an ultimate goal to have graduates who are competent in various STEM fields.

History of STEM education

In 1957, and right after Russia launched the first satellite called “Sputnik”, an excessive rise of criticism occurred on the educational system in USA. Afterwards, and specifically in 1983, several scientific reports on educations were published, yet, the most famous one was titles “A Nation at Risk”. The publishing of “A Nation at Risk” was considered an energetic stimulus that directed the Educational Reform at USA, and constructed a milestone in the American educational history (Butz, Kelly, Adamson, Bloom, Fossum & Gross, 2004). The report highlighted the failing of American schools system, which set off a call of action for reform (Ahmed, 2016).

In late 1990s, and in accordance with the National Science Foundation (NFS) political agenda, STEM education emerged for the first time in the USA (Sanders, 2009). STEM was introduced as an essential necessity for both professions and economic growth to rise the total number of students who have a preference to STEM fields; for the sake of ensuring America’s superiority in the global economy (Blackley & Howell, 2015).

On the word of Blackley and Howell (2015), STEM was initially introduced as an individual discipline. Then, engineering was added to the scientific field, which resulted in emerging of the STEM education concept. Later, the concept of integrated STEM appeared as result of identifying the clear relations between the four domains. It was primarily named SMET as an acronym constructed by using the first letter of these disciplines (Science, Mathematics, Engineering and Technology), but due to the unpromising feedback on the name, it developed into STEM in 2001 (Sanders, 2009). STEM used to describe an education or professional practices of those four disciplines (Sanders, 2012). In recent years, other important fields were added to it, such as **A**rts and humanities component to introduce the new term “STEAM” or **R**eading **and A**rts to modify it to “STREAM”, or Entrepreneurship and **D**esign, modifying the acronym eventually to ‘STEAMED” (Kanadli, 2019).

STEM Education Goals and Importance

The main purposes resulting from the merge of STEM education do have political and pedagogical backgrounds. STEM aims at building the students capabilities to become self-independent learners, by providing them with STEM topics, activities and practices that will enhance their critical thinking skills to develop positive attitudes towards STEM education and in return, STEM careers (National Research Council, 2011). STEM aimed to satisfy students' learning experience by helping them to transfer their learning in a different authentic context, where they can find or invent new solutions for real life problems based on their previous learnt and acquired skills (Blackley & Howell, 2015). Thus, STEM enhances students' interest to explore the world around them and involve them more in different learning process (Havice, Havice, Waugaman, & Walker, 2018). In other words, STEM aims towards increasing the number of students involved in STEM education, deepen students understanding of each discipline, encouraging students to choose STEM careers in their future professions, and raising students workforce skills to become STEM literate (Kanadli, 2019).

Many studies advocate the promising of STEM education approach and its significant effectiveness in well preparing students to fit in the high-level global marketing requirements (Chute, 2009; Daugherty, 2013; Sanders, 2012). In addition, STEM education has a remarkable impact on expanding students' 21st century skills by concentrating on solving problems, creativity, collaboration, communication and critical thinking. STEM reinforces the students' motivation in becoming critical thinkers, self-independent, inventors, innovators and technologically literate individuals (Morrison, 2006). Moreover, the application of STEM education builds the capacity of students by empowering their creativity and critical thinking skills. Furthermore, several studies pointed out the promising effectiveness of integrating science and mathematics instruction in raising the students' academic achievement in these fields (Havice et al., 2018; Kusurkar, Ten Cate, Vos, Westers & Croiset, 2013; Kanadli, 2018).

Definition of STEM Education:

Bruce-Davis, et al., (2014) and Al Basha, (2018) reported that there is disagreement on a specific definition for STEM education, yet many researchers attempted to provide definition that is developed along years.

In 2009, Morrison & Bartlett defined STEM education as an integrative approach to curriculum and instructional practices, characterized by removing boundaries between subject areas and taught them as one unit. Whilst Colorado Department of Education defined it as an interdisciplinary learning approach in which various scientific concepts are linked with authentic life lessons, where students implement different disciplines in one context that allow them to construct relations and connections between school and authentic community to help in developing economy (Tsupros, Kohler, & Hallinen, 2009).

Later on, in 2013, Johnson described STEM as integrated teaching instruction that links both science and mathematics with scientific practices and engineering designs. Furthermore, Kennedy and Odell (2014, p. 246) mentioned, "STEM is integration between subjects to eliminate the barriers between them", whereas Corlu, Capraro and Capraro (2014, p.75) stated that STEM is "a collaborative construction of knowledge and skills of more than one area of STEM subjects". Additionally, Kelly and Knowles (2016) described STEM as an approach that used to remove the barriers between two or more of STEM domains to enrich the learning process by their application in a context of a real-life problem.

Regardless of the differences in the previous definitions, yet all of them show some common aspects in between; of which STEM is an interdisciplinary approach that eliminates the boundaries between STEM domains, and provide students with opportunities to construct their own knowledge and concepts and develop and acquire more skills to apply them in an authentic context.

Teachers' Perceptions.

Perceptions are grounded on a social cognitive theory according to Martin & Guerrero (2020). Social cognitive theory describes the own person's beliefs and how they are going to reflect and influence their behavior and achievements (Martin & Guerrero, 2020). Additionally, regulation of the feelings, opinions and actions are dependent on how the person perceives them (Martin & Guerrero, 2020). According to social cognitive theory, the way a person acts is highly influenced by the constructed perceptions and expectations from their own life experiences and practices.

Moreover, researchers interpret the concept of perceptions in the scientific educational field as an individual's mental or intellectual point of view or ideas about a specific topic or event (Aksa, 2015). If these perceptions coincide with scientific interpretations, they are known as scientific perceptions, and if they contradict, then they are called alternative perceptions (Al Anzi& Al Gabr, 2011). Gonzalez & Kuenzi (2012) believe that perceptions are active process by nature that are subject to several factors. The most important factor is the individual's attitude and previous experiences.

In similar context, numerous studies highlighted the relation between different learning contexts and teachers' perceptions of teaching such as interest, awareness, concerns, and previous experiences. Such context, constructed an organized sequence of relations between teacher's approaches, students' learning approaches, their perceptions, and their learning outcomes (Srikoom, Hanuscin and Faikhamta, 2017; Prosser &Trigwell, 1999; Marton & Booth, 1997; Biggs, 1999). Accordingly, teachers' perceptions have a prominent influence on their decision-making, in addition to their teaching approaches, which comes as a result from the impact of their direct relationship with students (Trigwell, Prosser & Waterhouse, 1999). Figure (1) shows the relation between teachers' perceptions of teaching and quality of students' learning outcomes, as illustrated by Cope and Ward (2002).

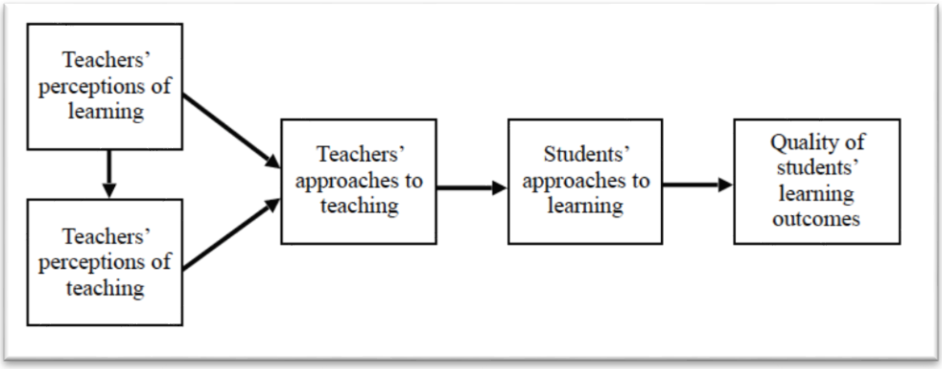

Figure (1) the relation between teachers' perceptions and students' learning outcomes adopted from Srikoom et al. (2017)

In the focus of STEM education, The National Research Council (NRC) (2007) stressed on the importance of teaching STEM at elementary level due to the early students' development of both perceptions and knowledge of STEM at that crucial stage. Appleton (2003) pointed out that teachers' attitudes, which resulted from their own perceptions towards STEM can enhance or hinder their interest to teach STEM. Therefore, the sense of transferring such attitudes from teachers to students, may lead eventually that students build negative attitudes towards STEM. Accordingly, the importance of improving knowledge of teachers in teaching STEM is of the same importance of considering and improving their perceptions.

Hence, in order to reach a stage where STEM education acts as an engine to increase STEM schools and teachers; there is a prior need to set a clear definition and description to STEM to avoid any negative attitudes or perceptions that could be associated with it as a term.

Consequently, investigating teachers' perceptions towards STEM education will provide correct information that will enrich the opportunity of developing new learning experiences, and correcting misperceptions and wrong beliefs towards the subject matter.

Teachers' Knowledge of STEM Education

In the current study, the first domain to investigate is teachers' perceptions towards STEM education knowledge. Knowledge is an examining situation that focuses on recalling, and recognizing of information related to a specific concept (Chan, Yeh & Hsu, 2019). Additionally, Thomson (1998) defined knowledge as individual awareness and familiarity of concepts, ideas, thoughts or objects of specific information. In general, many scholarly research papers focused on the significance of teachers' knowledge to deliver effective teaching and learning (Chan et al., 2019; Guerriero, 2017; Verloop, van Driel, & Meijer, 2001). In same vein, Allen, Webb, & Matthews, 2016; Saxton et al., 2014; Srikoom et al., 2017 highlighted the prominence of teachers' knowledge needed for an effective STEM teaching. Effective STEM teaching was described as a group of teaching practices that is based on teachers' knowledge such as; implementation of students centered pedagogies and engaging the students in various inspired contexts (Chan et al., 2019).

Teachers' knowledge for effective STEM teaching should be wide, rich, and multidimensional to enable teachers to plan, implement, modify and reflect on their STEM practices. Teachers' beliefs and perceptions regarding STEM education will affect the transformation of knowledge into instructional practices. Moreover, Chan et al. (2019) highlighted the use of teachers' practical knowledge for STEM teaching to describe teachers' own personal knowledge that will reflect on and guide their own practices. Therefore, teachers' knowledge acts as a generator for their instructions and practices.

Chan et al. (2019) established a structure for teachers' knowledge of STEM teaching. The structure enclosed four main components of knowledge apart from content knowledge. As shown in figure (2), the four knowledge components are curriculum, pedagogy, assessment and students. These components can be specified to a certain topic, domain, or can be generic in nature. In addition, there is variation in quality of knowledge and concreteness which can vary from general to more specific detailed, as shown in figure (2) (Chan et al., 2019). Moreover, the quality of teachers' knowledge varied according to different factors such as teachers' education background and their gained teaching experience (Chan et al, 2019). For instance, expert teachers have an extended knowledge base that provides flexibility in retrieving knowledge for teaching instructions and performance (Dreyfus & Dreyfus, 1986). Similarly, expert STEM teachers do not only have rich knowledge, yet they also have detailed and contextualized knowledge that can be used in various authentic real-life teaching contexts to provide a higher quality level of teaching (Chan et al., 2019).

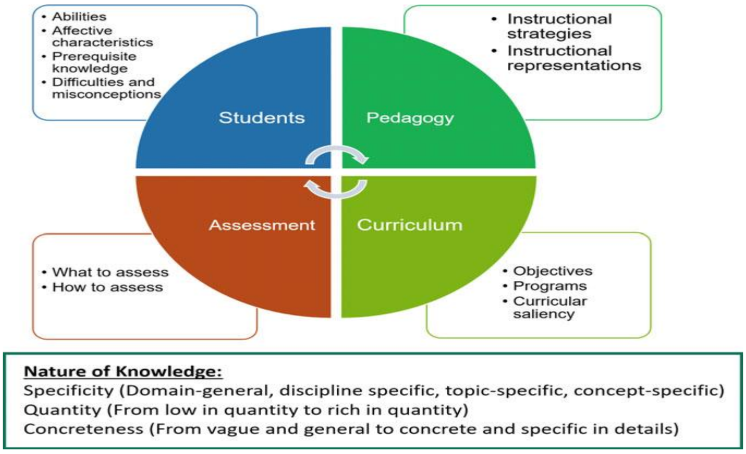

Figure (2) Teacher knowledge for effective STEM teaching adopted from Chan et al. (2019)

In the current study, STEM knowledge covered different dimensions of teachers' information, such as: a) characteristics nature of STEM education, b) goals of STEM education, and c) instructional practices of STEM.

STEM Teaching Requirements

In the focus of this study, STEM education is founded on constructivism theory and integration paradigm practices. In both, teachers are considered facilitators for the learning environment and process, where they provide students with authentic learning opportunities to enrich their learning experiences via deepen their understanding of STEM content domains (EL-Deghaidy, Mansour, Alzaghibi, & Alhammad, 2017). Moreover, teachers help students in constructing the relations between different disciplines and real-life while working collaboratively within their teams and applying their knowledge in real-life problems to invent creative solutions.

Consequently, teachers and students are crucial elements in identifying STEM teaching requirements. One of the vital elements of STEM teaching requirements is changing teaching instructions to shift students from knowledge recipients to knowledge producers via immersing students in inquiry-based, practical, project-based, and problem-solving practices that will improve their logical, creative, and critical thinking skills (Alsmadi, 2020). Hence, there is a necessity to improve students' 21st century and life skills; as there is a necessity to train students on various skills such as problem solving, analytical thinking, creative thinking, making decisions, entrepreneurship, teamwork and communication. Therefore, all these practices require teachers' awareness and readiness for various STEM teaching requirements (Alsmadi, 2020).

Impact of STEM Education on Students' Outcomes

NRC (2014) conducted literature review regarding STEM education impact on students' learning outcomes. They reported the significant influence of STEM education on both students and teachers (Kanadlı, 2018). Moreover, NRC (2014) emphasized that learning outcomes of STEM education for students do include, improvement in academic achievements, develop their 21st century skills, increase students' number enrolled in STEM fields' courses, development of STEM workforce, and increase in the interest of STEM, in addition to elevating the ability to express understanding between different STEM disciplines. On the other hand, NRC (2011) specified that the learning outcomes for educators is evident in the effective implementation of instructional strategies, which will increase engagement of students in inquiry and design based learning, and the improvement of STEM pedagogical content knowledge.

Additionally, STEM education enhances the development of various students' skills such as life, psychomotor, problem-solving, critical thinking, engineering and design, inquiry and 21st century skills (Kanadlı, 2018). MoNE (2013) stated that life skills involve analytical thinking, creative thinking, decision-making, entrepreneurship, teamwork and communication. Whereas they defined 21st century skills to encloses of communication, collaboration, critical thinking, problem solving, creative thinking, decision-making, and metacognition (Çepni & Ormancı, 2018). The significance of acquiring these skills will reflect on both cognitive and personal development of students, which will adapt them more to challenges in their professional lives in the future (Ontario, 2016).

In affective dimension, STEM education arouses students' interest and curiosity, which will enhance their motivation to learn. Motivation has a crucial influence on education, because a student's motivation can directly contribute in a positive manner to their academic achievement (Kusurkar, Ten Cate, Vos, Westers & Croiset, 2013; Kanadli, 2018). In addition, STEM education empowers students' development of responsibility, positive attitudes, self-confidence, and raises their awareness of real life problems (Kanadlı, 2018). Finally, STEM education supports the development of students' positive attitude and interest in STEM fields, which will have an influence on increasing their interest in STEM careers in the future (Yildirim, 2016; Nite et al. 2017; Kanadlı, 2018).

Challenges hinder STEM Implementation

In spite of the great focus on STEM education, yet there are several challenges that hinder its implementation (Thibaut et al., 2018; Kanadlı, 2018). Kanadli (2018) identified the common limitations in the inappropriateness of curricula, difficulty and time-consuming in planning and implementation, difficulty to apply it in crowded classes, and insufficient equipment and resources due to its high cost. Moreover, Nadelson and Seifert (2017) stressed the need to restructure curriculums to align constructively with the discipline-based structure of STEM. Consequently, establishing a school environment that supports STEM education can be time-consuming and expensive (Nadelson and Seifert, 2017; Kanadlı, 2018; Hardy, 2001).

Moreover, schools' inability to provide qualified STEM teachers, as STEM teachers should have a deep understanding of the four STEM disciplines' content and their pedagogical practices (Thibaut et al., 2018; Eckman et al., 2016). As per El-Deghaidy and Mansour (2015), teachers reported that from the challenges that hinder their implementation to STEM, is their feeling of not being prepared enough to implement it effectively in classes and their inadequate understanding of some disciplines of STEM such as "Technology" and its interaction nature with science. Moreover, Ashgar et al. (2012) specified that teacher's beliefs, views, practices and willingness to change their mindset, could be another crucial challenge of implementing STEM.

STEM Professional Development Programs

Reviewing literature related to the positive effect of professional development programs on both practices of teachers and students' outcomes varied according to the characteristics and the provided professional development programs' quality (Nadelson et al., 2013; Capraro et al., 2016). On Contrast, low quality programs have insignificant impact on students' outcomes (Nadelson et al; Capraro et al., 2016). To ensure a high quality professional development program, its design should be constructed according to the teacher's needs, essential content knowledge, and includes the pedagogy (Du et al., 2018).

Desimone (2009) suggested a "core conceptual framework" for the construction of effective professional development programs. The core conceptual framework is based on five key features that has great impact on teachers' practices and experiences. Johnson et al. (2017) stated five key factors as follow: content focus in which the program should concentrate on the real content that the teacher is going to implement later. Second, is the active learning; in which the teacher has an opportunity to experience the students ‘role within the workshop to help them reflect and evaluate the best ways to teach and enhance learning. Third key feature is the coherence, in which the program alignment is compatible with the policy of the schools that facilitate the teacher’s application later. Fourth, is the duration of the program, which should be 80 hours along the academic year; so teachers can implement and reflect on their implementation to improve it. Finally, the collective participation that allows teachers from the same grade level or same subject to interact through the program and share their experiences together; which eventually has a great influence on advance developing of their teaching practices (Johnson et al., 2017).

In STEM, many studies such as Rinke, Gladstone-Brown, Kinlaw, and Cappiello (2016) and Johnson et al. (2017) specified in their findings that the main factor for building STEM professional development program apart from STEM content is STEM pedagogical skills. Recent researchers and academics such as (Al Aitebey, 2018; Al Anzi& Al Gabr, 2017; Du et al., 2018; Wang et al., 2011; Nadelson, 2013) stepped forwards in appraising the effect of STEM professional development programs on changing science teachers’ perceptions. All of them confirmed the positive impact of different STEM programs on changing teachers’ perceptions and practices towards STEM education and its implementation (Wang et al, 2011, Al Aitebey, 2018; Al Anzi& Al Gabr, 2017; Nadelson, 2013; Du et al, 2018).

STEM in the Elementary Curriculum

Several recommendations from STEM education literature reported that learning STEM should start at elementary stage to develop students’ interest, essential basic knowledge and skills, which will act as a crucial factor for students’ success in high schools (Belden, Lien and Nelson-Dusek, 2010; Aydin, 2020). Brenneman (2014) elaborated that implementation of STEM education from elementary stage guarantees the knowledge development of different disciplines, and improvement of numerous skills such as mathematics and reading skills that are considered as a base for scientifically literate students. Furthermore, it will increase students' engagement in learning and students' interest in STEM field, which will eliminate the gender gap in STEM fields (Xie, Fang and Shauman, 2015; Belden, Lien and Nelson-Dusek, 2010, Aydin, 2020).

In the State of Qatar, the new science curriculum developed in 2018 is aligned with the objectives of Qatar National Curriculum Framework (QNCF) to ensure students gain science knowledge, and develop skills and positive attitudes; to achieve the goals and outcomes of the education system. The major key changes to science curriculum enclose assimilation of skills and processes correlated to scientific inquiry into other strands named competency. Competencies in science includes five main components: Inquiry and Research, Communication, Critical and Creative Thinking, Co-operation and Participation, and finally Problem-solving (*Qatar Science Curriculum*, 2018)

The main aim of the Science curriculum is to deliver a valuable educational experience for all students within and beyond school. Moreover, enable them to develop positive attitudes and develop essential skills and knowledge. In response, students will become active, confident and responsible citizens in the global based economy and will become well prepared as lifelong learners who are scientifically literate in the 21st Century (Qatar Science Curriculum, 2018).

Additionally, science is a dynamic and collaborative human endeavor with links with other subjects and cross cutting issues as identified in the QNCF. Frequently science issues may intersect in one or more subjects or areas within their context. These crosscutting issues may provide appropriate learning context and deepen the understanding of science and its intersection with other subject areas (Qatar Science Curriculum, 2018).

Several factors are considered as an opportunity for implementing STEM education within current science curriculum. Science curriculum stems from scientific inquiry and key competences in science learning that is aligned with main practices and STEM skills (*Qatar Science Curriculum*, 2018). In addition, science curriculum is based on inquiry-based strategies that engages students in meaningful learning experiences that cultivates their interest and curiosity and provides new authentic experiences for students beyond school teaching. Furthermore, the presence of cross cutting issues; deepens the understanding of scientific concepts through different disciplines (Qatar Science Curriculum, 2018). However, it is worth mentioning that STEM was not stated in the curriculum standards of elementary stage.

STEM Education in Qatari context

The State of Qatar has occupied broad paces in shifting its society into regional educational hub via reform of its full educational system (GSDP, 2012). In late 90s, there was huge dissatisfaction with the educational system in the State of Qatar, which was highlighted in the low-quality outcomes of the Qatari students and their academic achievement, attending college and meeting successful standards of labor market. Consequently, the leadership assigned RAND Corporation to evaluate the education system from kindergarten through grade 12 and to design reform plans to help in qualifying Qatar to meet its need and to be aligned with global standards (Brewer et al., 2007). Subsequently, as per Qatar National Vision 2030, the State of Qatar targeted specific goals to be achieved by year 2030 to shift from hydrocarbon economy dependence to the knowledge-based economy where STEM field is a major focus of these plans (Sellami et al., 2017).

Several studies such as (GSDP 2011; Shediac & Samman Sellami et al., 2017; Abdulwahed et al., 2013) reported shortage of qualified Qatari citizens in STEM fields. Currently, the workforce relies mainly on the foreign experts rather than Qatari nationals (Sellami et al., 2017). Similar to the Arab Gulf states, the State of Qatar countered this insufficiency by hiring qualified workers from all over the world (Sellami et al., 2017). On the other hand, there is great focus highlighted from educational reforms on the importance of STEM education as a foundation asset for constructing the future of Qatari knowledge society (Oxford Strategic Consulting, 2015, 2016; Sellami et al., 2017; Barnett, 2015; Wiseman et al., 2014).

Consequently, the Ministry of Education and Higher Education (MOEHE) in the State of Qatar adopted the initiative of STEM projects to reflect on the first pillar in human development and the second pillar in economic development of the strategic planning of Qatar Vision 2030 (QNV 2030). Correspondingly, MOEHE attempts to achieve the strategic goal to raise the percentage of secondary school students enrolled in STEM specialized fields by developing the vision of Qatar Science and Technology Secondary School (QSTSS) which was open in 2018. Moreover, the project of QSTSS has been finalized in accordance to its operational plan by the announcement of receiving the international accreditation from the “Advanced” organization and the inauguration of grade 11 starting of the academic year 2020- 2021 (Al-Khater, 2021). In addition, there has been an opening to the first technical school for girls, and there is an intention to open two extra schools for STEM for both gender in the near future (Al-Khater, 2021). Lastly, the Education Affairs Sector of the MOEHE revealed the launch of new initiative for horizontal expansion of the STEM education in public schools via the implementation of various STEM programs in primary, preparatory, and secondary schools.

Therefore, to accommodate this new initiative for horizontal expansion of STEM education in public schools in the State of Qatar, investigating science teachers' perceptions towards STEM education in primary public schools will be an initial step for providing useful information to enrich the effective STEM implementation in the future.

1.1 Research Problem

The results of primary students at public schools in National Exams (2017- 2018) indicated students' low level of knowledge and skills in Math and Science (School Evaluation Department- Evaluation Affairs Sector, 2018). Moreover, Qatar contributed in the Trends in Mathematics and Science Achievement (TIMSS) for four years (2007, 2011, 2015 and 2019) to gain a clear insight of students' knowledge and skills in both science and mathematics. TIMSS 2019 reported that there is an improvement in the average achievement across the assessment years in both subjects for grade four students. However, the results of TIMSS 2019 highlighted that Qatar's performance is still below the average level compared to other countries (Mullis, Martin, Foy, Kelly & Fishbein, 2020).

As per the summary of education report for the academic year (2017-2018), it is highly recommended to raise students' outcomes in Math, Science and English. Additionally, the report called for the alignment between students' outcomes and teaching instructions, which pointed out the crucial necessity to improve the instructional methods to enhance students' abilities and their higher order thinking skills (School Evaluation Department- Evaluation Affairs Sector, 2018). Therefore, MOEHE in Qatar sustains professional development opportunities for teachers to keep them compatible with most effective and updated instructional methods and improve their performance, which will be reflected on students' outcomes in general and on students' achievement in international exams as TIMSS in specific.

To this end, MOEHE adopted the initiative of STEM education in Qatar. STEM education causes a fundamental transformation in classrooms. It shifts them into creative, integrated disciplines nature, and converted the teacher's role to facilitator of learning process who guides students towards exploration, investigation, problem solving and enhance their motivation to think critically to develop different creative solutions for real life challenging problems (Ahmed, 2016). Accordingly, in 2018 MOEHE established Qatar Science and Technology Secondary School (QSTSS), which is specialized in STEM education. QSTSS aimed at providing learning outcomes that possess 21st century skills and raising the percentage of secondary school students enrolled in STEM specialized fields. Consistently, the Education Affairs Sector of the MOEHE revealed the launch of a new initiative for horizontal expansion of the STEM education in public schools via the implementation of various STEM programs in primary, preparatory, and secondary public schools.

Additionally, findings from previous literature specified that teachers' practices in STEM education are strongly affected by their perceptions, which arose from their level of understanding of integration between STEM disciplines and demanding teaching requirements (El-Deghaidy & Mansour, 2015; Ambo Saedey, Al-Harthy &Al Shehemy, 2015; Wang, Moore, Roehrig& Park, 2011). Therefore, assessing teachers' perception of STEM education will provide valuable input for developing new learning experiences, and sustaining STEM deployment (Khuyen et al., 2020). In a similar vein, there are several studies on science teachers' perception in different regions of the world; however, most of the studies published in MENA region were conducted on KSA teachers' perceptions except for AL Basha (2018) which was conducted in UAE, and Elayyan and Al- Shizawi (2019) in Sultanate of Oman. Accordingly, – to the Researcher's knowledge–, there is still an urgent need for more research work on this topic using different approaches in the Arab region in general and in Qatar in specific.

Therefore, the current study fills a gap in STEM education research field, generally in MENA, Arab region and in Qatar specifically, as it targets to investigate primary science teachers' perceptions towards STEM education and identify the obstacles that may hamper its implementation in primary public schools in the State of Qatar. Additionally, it will identify if there is any variance in teachers' perceptions related to different variables such as gender, their educational background, their teaching experience, received professional development programs and STEM teaching experience.

1.2 Research Questions:

This research study aimed to answer the following research questions:

1. What are science teachers' perceptions towards STEM education in public primary schools in Qatar?

   This question will be answered through the following sub-questions:

   i. What are science teachers' perceptions of STEM education knowledge in Qatari public primary schools?

   ii. What are science teachers' perceptions of STEM teaching requirements in Qatari public primary schools?

   i. What are science teachers' perceptions of the impact of STEM education on students' outcomes in Qatari public primary schools?

   ii. What are the science teachers' perceptions of the challenges facing STEM implementation in Qatari primary public schools?

2. Do science teachers' perceptions towards STEM education differ due to gender or educational background or teaching experience or the received professional development or STEM teaching experience?

To answer this question, the study will examine the following statistical question:

Are there any statistical significant differences (α= 0.05) in the primary science teachers' perceptions due to gender, educational background, teaching experience, the received professional development programs, STEM teaching experience?

1.3 Research Objectives:

1. Identify science teachers' perceptions towards STEM education in public primary schools in Qatar, regarding four main domains: STEM education knowledge, STEM teaching requirements, the impact of STEM education on students' outcome and the challenges that may hamper its implementations.

2. Assess the significant differences among science teachers' perceptions related to demographic variables such as gender, educational background, teaching experience, the provided STEM professional development programs and STEM teaching experience.

1.4 Research Significance:

First, the significant of this study attributed to the contribution of its findings to STEM field with empirical data from science teachers in the primary public schools of Qatar. Additionally, its results would provide clear understanding of science teachers' perceptions towards STEM education, which is a primary step in effective implementing of STEM education in primary public schools. Moreover, research results would update stakeholders and policy makers on challenges that may face its implementation. Furthermore, it would provide recommendations to introduce new professional development programs for in-service teachers. Moreover, it will highlight the historical and theoretical background of STEM education. Finally, it will fill the current literature gap regarding teachers' perceptions of STEM education in MENA region and motivate other researchers to conduct further studies to investigate more teachers' perceptions from other grade levels.

1.5 Theoretical Framework:

Theoretical framework of STEM education stemmed on both social constructivism theory and instructional practices as shown in figure (3) (Thibaut et al., 2018).

Figure (3) Theoretical framework for STEM education adopted from Thibaut et al. (2018)

1.5.1 Social Constructivist by lev Vygotsky

Constructivism is a huge theory usually used in educational community, whenever there is a school discussion related to methods for teaching and learning (Powell & Kalina, 2009). Most of classrooms encompass two major types of constructivism named as cognitive constructivism and social constructivism.

Cognitive constructivism resulted from Piaget's work. He emphasized that learning is constructed, where new knowledge built on the existing knowledge and expanded more through various learning experiences, so it become meaningful and more relevant (Phillips, 1995). It is hard to explore the scopes and differences of constructivism, but the most extensive interpretation is that constructivism enhanced teaching to be students centered and inquiry-based oriented. Constructivism approaches encompass students investigating authentic problems, analyzing and discuss findings, thinking critically, making new connections and exploring new concepts.

Subsequent to Piaget's cognitive constructivism theory, Lev Vygotsky founded the social constructivism and became the father of this highly effective theory. He believed that social interaction is a vital part of learning. Social constructivism was established based on the social communications and various interactions of students aligned to their individual critical thinking (Powell & Kalina, 2009). Social constructivist emphasized on the importance of cooperative work between learners, where they discover and explore different resources and use them in inquiry-based experience (Vygotsky, 1978; Powell & Kalina, 2009). All Vygotsky's theories enclosed cooperatively in both social constructivism and language development such as the zone of proximal development, social interaction and cognitive dialogue (Vygotsky, 1962). Conclusively, Vygotsky's theory established the development of effective classrooms where the social interaction is crucial (Powell & Kalina, 2009).

In STEM education, the integration is endorsed to support students' constructing new connections and relations between various ideas (El-Deghaidy et al., 2017). According to brain research, developing significant connections between previous and new knowledge and between different disciplines provide a great opportunity to develop schemas that enhance cognitive skills and deepen the learning (Beane, 1996). Consequently, STEM education supports constructivist approaches in learning, where teachers act as a facilitator for the learning process by scaffolding students' learning (Becker & Park, 2011; Cunningham & Cordeiro, 2006; El- Deghaidy et al., 2017).

1.5.2 STEM Instructional Practices

STEM education depends on various instructional practices such as integration of STEM content, as well as problem-centered learning, inquiry-based learning, and design based learning, and promoting collaboration to connect students with their authentic community (Kennedy & Odell 2014; Thibaut et al., 2018).

Integration of STEM content

Integrated curriculum development was highly supported by Susan Drake in 1980 and 1990s. Integrated curriculums increase the students' academic achievement in comparison to their achievement in individual disciplines (Drake and Burns, 2004). Drake classified integration into three main categories according to the degree of separation between discipline areas; multidisciplinary, interdisciplinary and transdisciplinary as shown in figure (4).

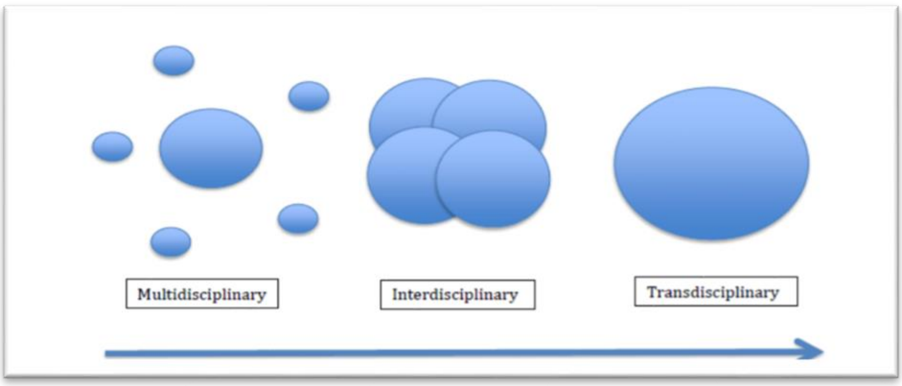

Figure 4: Continuum of Integration. Adapted from Drake (1991).

Multidisciplinary approach encloses different subjects within a definite theme activity. This theme exploration is from multidiscipline dimensions where the knowledge and skills are merged within certain curricula as in figure (5). In this approach, identified concepts from different disciplines and several skills are acquired individually within separate discipline; later students start linking the content from different disciplines on their own (Wang et al., 2011). Moreover, interdisciplinary approach in which there is obvious overlapping and connections between different subjects' content, while curriculum organization established among definite disciplines to express numerous skills and concepts as in figure (6). An interdisciplinary approach usually started with authentic world problem and emphasis on interdisciplinary content and skills such as problem solving and critical thinking, rather than individual subject content and skills (Wang et al., 2011). Furthermore, transdisciplinary integration in which there is no real barriers between subject areas and curriculum organization based on authentic life contexts where students' skills are widely practiced and acquired as in figure (7).

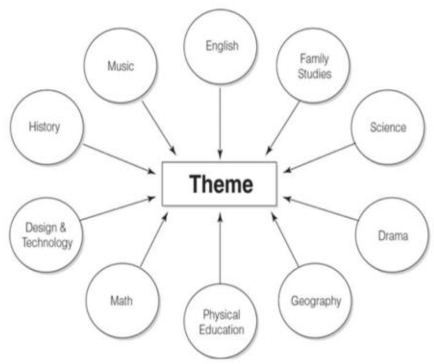

Figure (5) Multidisciplinary approach according to Drake (1991)

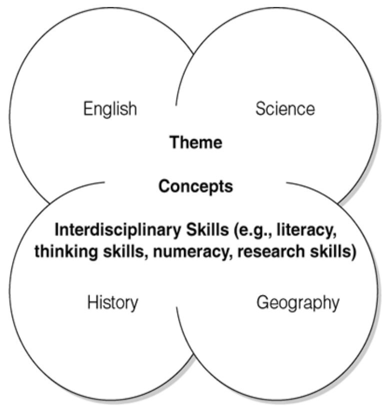

Figure (6) Interdisciplinary according to Drake (1991)

Figure (7) Transdisciplinary approach according to Drake (1991)

Integration in STEM education advocates building connections between different STEM disciplines. There are two approaches of integration in STEM education: content integration and context integration (Moore & Smith, 2014). Content integration aims at fusing the different disciplines into single curricular unit to focus the main concept from multidimensional content areas, whereas in context integration the focus is on the content of single discipline and use the contexts from other disciplines as motivating tools to increase the significant of the content (Roehrig et al. , 2012). Accordingly, STEM curricula established on these integration approaches encompass digital formatting, inquiry, problem-based learning, constructivist teaching instructions, interdisciplinary approach and design based learning (Al Basha, 2009).

Many research such as (Satchwell and Loepp 2002; Person, 2017; Shahali et al., 2017; Stump et al., 2016) highlight the prominence of explicitly integrating concepts from different STEM disciplines as students cannot suddenly integrate concepts via various illustrations and resources on their own. Thus, intended scaffolding for students to construct new knowledge and acquires new skills among different fields must be highly supported (Person, 2017). On other hand, (Guzey et al., 2016; Pearson, 2017) reported that integration in STEM should be on purpose and meaningful, and students should be supported to build their knowledge in individual disciplines, so they deepen their understanding of concepts in individual disciplines and therefore connect concepts across different disciplines.

Problem centered learning

Problem-centered learning require using authentic world problems within an engaging context (Thibaut et al., 2018). It focuses on implementation and transmission of knowledge in authentic contexts, where problem-solving skills are clearly recognized as an added outcome (Merrill, 2007; van Merriënboer and Kirschner, 2007). It also encloses both project-based learning and problem-based learning. Both approaches are common in using real-life problems, students centered learning, enhancing active learning, despite the existence of some difference (Ashgar et al., 2012).

STEM Project-based learning (PBL) is defined as an integrative approach commonly interdisciplinary usually initiated with a task to solve a definite problem by investigating and innovating solutions and designs to create products (Han et al., 2015; Capraro and Slough, 2013). Kokotaski, Menzies, and Wiggins (2016) highlighted the impact of PBL in enhancing students' high thinking skills as they face some cognitive challenges occurred during the creation of different designs; this will in turn increase students' intrinsic motivation and independence (Ashgar et al., 2012). Gonzales (2015) specified that PBL help students in developing cooperation, communication, collaboration, critical and creative thinking skills. In addition, PBL follows the engineering design process, which enhances the development of metacognitive skills via trial and error (Hall and Miro, 2016).

In contrast, there is no product in problem-based learning, however students identify and describe the problem on their own, and present a new solution for this problem. Thus, problem-based learning improves students' problem-solving skills by experiencing authentic open-ended problems. Despite the differences between project-based learning and problem-based learning, both had mutual aspect including the requirements of the introduced problems to be open-ended, authentic, unstructured, real-life authentic problems (Burrows et al., 2014; Satchwell and Loepp, 2002; Shahali et al., 2017). Such problems reflects challenges faced by scientists and engineers in real life and aim to enhance learners' innovation and creativity skills to apply in different contexts (Ashgar et al, 2012).

Inquiry based learning (IBL)

Inquiry-based learning is a crucial instructional practice of STEM education. Although it is considered the heart of science education, it is not restricted to this domain and can be implemented in different contexts such as mathematical or technological contexts (Satchwell and Loepp, 2002). It engages students in authentic practices to discover new concepts and build on their prior knowledge to deepen their understanding through engaging hands-on activities (Satchwell and Loepp, 2002). Inquiry-based learning based on constructivism theory, as it enhances knowledge construction through investigational learning (Wells, 2016).

Wells (2016) highlighted the important aspects of inquiry-based learning. It is always initiated with questioning, where students are stimulated by engaging questions to review their prior knowledge on the targeted topic to define the main problem and identify the new concepts and knowledge required to investigate (Stump et al., 2016; Wells, 2016). Accordingly, students are motivated to make predictions, design experiments to test their hypothesis, observe, collect data, analyze it, explain their findings and develop new concepts (Satchwell and Loepp, 2002; Stump et al., 2016; Wells, 2016). Furthermore, students should be engaged in scientific argumentation and discussion, where they claim and justify them based on their data (Macdonald, 2016). Students are not restricted to investigate new concepts through investigation only; they need to apply their new concepts in different contexts to demonstrate their deep understanding (Satchwell and Loepp, 2002). Finally, teachers guide students by asking questions to redirect their thinking, discover flaws in their process or design and help them to analyze their finding to discover new concepts (James et al., 2000; Satchwell and Loepp, 2002; Buck et al., 2008).

Design based learning

Design based learning refers to the application of technological or engineering design (Thibaut et al., 2018) . One of the main goals of STEM education is engaging students in actively engineering challenges. Engineering challenges offer students an opportunity to learn more about process and practices of engineering design, and to expanding their understanding of various concepts through different disciplines (Guzey et al., 2016; Hernandez et al., 2013; Shahali et al., 2016). Thus, engineering design practices empower knowledge of students in different STEM disciplines, as it builds clear connections between content knowledge, abstract knowledge and application (Riskowski et al., 2009).

Engineering design challenges are characterized by being authentic, multidisciplinary, and open-ended (Shahali et al., 2016). Marulcu and Barnett (2016) identified that engineering practices construct connections with community and societal needs due to their authentic nature. Moreover, Guzey et al. (2016) indicated that engineering design challenges allows students to investigate, use information, search for more information to develop solutions and test their designs. Thus, engineering and scientific inquiry practices cannot be separated as per Krajcik and Delen (2017) as they share several phases. Engineering design process as shown in figure (8) involves several phases such as questioning, defining problem, searching and design a model, building and testing model, evaluating the model, and lastly adjusting and redesigning (Bryan et al., 2015; Wells, 2016).

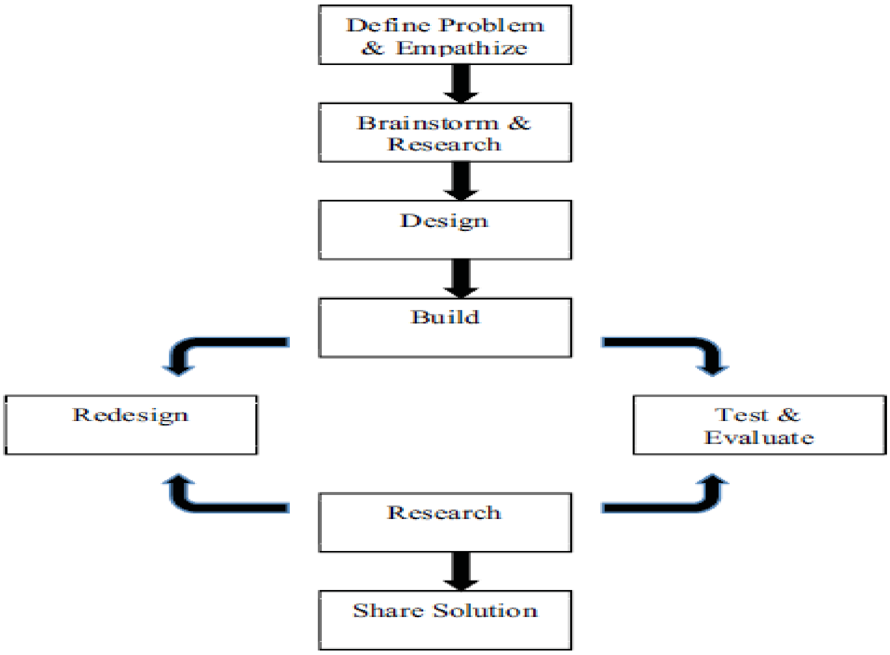

Figure (8) engineering design process (adopted from Lesseig, et al. 2016)

Finally, engineering design process motivates students to manage threats, learn from their mistakes and consider their prior experiences and practices (Bryan et al., 2015; Guzey et al., 2016).

Collaboration learning

STEM education involves the contribution of collaboration and teamwork. STEM education guarantees that students can learn by fun, which will actively engage them in learning process within their cooperative groups (Land, 2013). According to NRC (2011), effective STEM education should focus on students' interest and their previous experience to build on it. Thus, STEM education support students' active participation within their groups via using various practices such as inquiry, problem solving, constructivist teaching approach and performance based (Land, 2013). Guzey et al. (2016) stressed on the need to provide students with necessary time and multiple chances to allow their involvement in teamwork, which will improve their communication and social skills. Furthermore, (Bryan et al., 2015; Roehrig et al., 2012; Stohlmann et al., 2011) highlighted the prominence to enhance the communication skills by encouraging students to communicate different STEM discipline concepts via listening, reading, writing and speaking. Last, positive interdependence is crucial aspect between group members because students should work within their groups only on compatible tasks to their cooperative learning (Ashgar, et al, 2012). Thibaut et al. (2018) pointed out that achievement of positive interdependence could be via assigning tasks that cannot be achieved individually, sharing resources through different activities and tasks and rewards for successful interdependence.

1.6 Operational Definition:

STEM education: is an approach interdisciplinary in nature, used to remove the barriers between STEM domains (science, technology, engineering and mathematics) to enrich the learning process by their application in a context of a real-life problem.

Perceptions: it as a set of opinions and ideas constructed by individuals about specific topic through their own experiences and practices, resulted in ideas produced during the research process.

Knowledge: individual awareness and familiarity of concepts, ideas, thoughts or objects of specific information.

1.7 Limitations of the Study

This study has one limitation where focus groups were planned to include four to five participants within each group, but the Covid-19 pandemic vented this composition of focus groups, so only groups of three participants were convened.

Chapter Two: Literature Review

The current study investigated science teachers' perceptions towards STEM education. This chapter addresses reviewing literature related to teachers' perception towards STEM. The first section explores the studies that were conducted within the MENA (Middle East and North Africa) region, while the second section focuses on studies implemented in other regions. Moreover, the presentation of the literature follows upward timeline of publication dates from the old to the recent.

2.1 Studies in MENA Region:

El- Deghaidy & Mansour (2015) tackled the area of science teachers' perceptions towards STEM education and its integrative nature and identified the required aspects that facilitate and hamper STEM implementation in Saudi schools. The study elicits science teachers' perceptions using qualitative methodologies. Teachers' focus group, teacher-reflection and interview protocol were the instruments for collecting qualitative data. Results reported that teachers' perceptions influence their implementation of STEM education, especially upon understanding the nature and interaction of science and technology. Additionally, teachers believe that inclusion of STEM may require a school culture that emphasizes the exchange of experiences and the ongoing discussion among teachers and school management. The study highlighted some recommendations that could enhance a professional development model of different pedagogical content knowledge according to teachers' need to enhance the implementation of STEM education in class.

As for Al Anzi and Al Gabr (2017), the study attempted to evaluate science teachers' perceptions level towards STEM and its relation to several variables such as teaching experience and teaching grade level. The researchers applied the descriptive approach. They used a "survey" as the main instrument for their study. The survey consisted of two main sections: STEM knowledge, and STEM teaching requirements. The questionnaire was implemented on a random sample of 136 science teachers in Medina. Analysis of data indicated that there was high perceptions' level for both tested domains; STEM knowledge and its teaching requirements. Moreover, results reported that the absence of statistically significant differences between teachers according to their teaching experience. On contrast, there were significant differences due to the teaching grade level for science teachers. The study recommended implementing more training workshops to clarify the characteristic nature of STEM and its planning and implementations within science instructions. In addition, the study suggested to focus on implementing more programs for teachers' preparation according to STEM interdisciplinary and in science curriculum.

Similarly, AL Aitebey (2018) used a questionnaire to assess teachers' perceptions level towards STEM at Afif Province in (KSA). The researcher used the descriptive approach. The questionnaire consisted of 30 statements with two main sections: Teachers' perceptions about STEM knowledge and Teachers' perceptions about STEM teaching requirements. The sample included 206 teachers for all grade levels. The findings reported the presence of statistically significant difference between genders in teachers' perceptions of STEM on the side of female teachers, in addition to presence of a statistical significant level of (0.01) in teachers' perceptions of STEM according to their specialty. At the end, the researcher recommended implementing more studies on the impact of STEM training program on teachers' performance.

Furthermore, a recent study by Al Basha (2018) to examine STEM subjects' teachers perceptions and implementation practices in American schools in the United Arab of Emirates (UAE). The study implemented a mixed method approach for collecting data. A sample of 144 in service teachers were surveyed to assess their perceptions and practices, followed by individual interviews with some teachers. The results pointed out that most of STEM teachers' in UAE had high perceptions of STEM education. Project- based learning is frequently used to implement STEM as a part of curricula or as a monthly activity. Findings showed that engineering concepts were presented while engineering practices were understated. The findings revealed the need of further understanding of various disciplines' concepts and instructions for effective collaboration. Generally, teachers from both middle and secondary schools in the UAE showed constructive perceptions of STEM more than elementary teachers, which was reflected on their implementation.

In a major advance in 2019, Madani and Forawi used parallel mixed method to examine teacher's perceptions and practices of both new curricula of Science and Mathematics in KSA. The researchers used teacher's interviews and classroom observations for collecting qualitative data and a questionnaire for collecting quantitative data. The sample consists of 547 high school mathematical and science teachers. Findings indicated that there is a need to clarify what should STEM education look like. In addition, the study identified the main points that are considered as a pace towards implementation of STEM education, such as: transforming teacher's role as facilitator, train students to use different resources to attain knowledge required for solving real life problems, and provide administrator support via effective professional development programs. Conclusion from qualitative and quantitative analysis verified that teachers have positive perceptions towards STEM education in terms of increasing their confident upon dealing with new math and science curricula, implementation of STEM instructional practices, and their ability to manage whole class students in projects based activities. Moreover, there is no difference in teachers perceptions in relation to gender or educational qualification , while the differences is reported in relation to teaching experience in favor to teachers with high teaching experience. The major recommendation for the Ministry of Education to increase STEM concepts experience among students and teachers at all levels.

In the same vein, Elayyan and Al- Shizawi (2019) study focused on examining science teachers' perceptions of integrating STEM in AL Batinah North Governorate in the Sultanate of Oman. A descriptive methodology was implemented using 19 items questionnaire. Targeted sample consisted of 147 science teachers (71 males and 76 females). Findings indicated high perceptions of science teachers towards integrating STEM in teaching science. The study recommended modifying science curricula by adding engineering design process to it, and implementing more workshops to train teachers on formulating questions within real problem contexts.

Moreover, Al- Salamat (2019) examined the perceptions of science teachers in KSA secondary schools on STEM integration and identified if there are any statistical significant differences in these perceptions concerning teaching background, teaching experience and specialty. A Questionnaire was used to identify the perceptions of 56 male science teachers from Secondary schools in Taaif. Results showed the presence of high perceptions towards STEM integration. In addition to the presence of statistically significant difference in reference to teachers of postgraduate studies and higher teaching experience. Finally, there was no difference attributed to the science specialty.

Finally, Madani (2020) investigated science and mathematics teacher's perceptions on STEM implementation in Jeddah secondary schools in KSA. The researcher used the interviews and classroom observations to collect qualitative data from eight teachers. Results pointed out that there was a degree of imprecision in both science and mathematics teachers' definition and explanation of STEM main concept and its practices. Moreover, the new teaching strategies used in the new curricula as per recommendation by the Ministry of Education were equivalent to effective teaching practices required for successful STEM education implementation.

2.2 Studies in Other Regions:

In similar context to the above studies in MENA region, Wang et al. (2011) piloted a case study on three teachers to deepen understanding of teacher's beliefs, perceptions and classroom practices using STEM integration approach. The researchers purposefully selected the sample from middle school teachers who received STEM integration professional development program for one year, to represent science, math and engineering teachers. Qualitative and quantitative data collected using document analysis, classroom observations and teacher interviews. Constant comparative method was used to analyze data. Findings from the study stated that the key component to integrate STEM discipline is the use of problem solving approach. Teachers had different perceptions of STEM disciplines integration according to their specialty. The hardest discipline to integrate was the technology. Teachers were aware of their needs to increase the content knowledge in their STEM integration practices.

Moreover, Brown, Brown , Reardon and Merrill (2011) used the survey on their study to explore both teachers and administrators' perceptions of STEM education. Qualitative data was a result of interviewing 172 teachers from different fields (Science, Math & Technology) and administrators. The research concluded that teachers need further understanding for STEM education, as there was no clear vision for STEM education even for teachers who believe of its importance. Finally, a minor sign of STEM existence in the school appeared in the survey, and that highlighted the absence of collaboration among teachers.

Furthermore, in 2013 Nadelson et al. made further investigations for impact of STEM-based professional development programs on the perception and preparation of STEM teachers at the primary level. The researchers designed and implemented a STEM-based questionnaire to address teachers' confidence, knowledge, perceptions and self-efficacy in teaching inquiry-based STEM. The study followed the experimental approach of two independent cohorts' primary school teachers over a two-year period. The sample consists of 33 teachers from diverse primary schools in the southern United States of America. The researchers used four types of pre/post questionnaires to collect data on teachers' confidence, knowledge and effectiveness in teaching STEM, as well as the change in their attitudes after the implementation of the program. The results indicated a significant impact of the training program on developing the level and capabilities of all teachers in teaching STEM. In addition, findings revealed that confidence, knowledge and effectiveness have increased among teachers. The two-year outcomes also emphasized the positive impact of short-term professional development programs on the knowledge, perceptions and effectiveness of teacher practices of STEM.

In the same vein, Bell (2016) explored how design and technology teachers perceive STEM and identified the range of variation in their perceptions regarding design and technology pedagogy. The researcher adopted phenomenography methodology to explore teachers' perceptions and pedagogical understanding of non-dualistic ontological approach. Nineteen interviews were conducted, followed by data analysis to construct empirically grounded outcome. Findings from analysis highlighted that teacher's perceptions of STEM and personal understanding of knowledge was correlated to efficiency of their STEM practices in their own classrooms. Conclusion emphasized that in order to develop well STEM literate students, all STEM subject teachers must be sustained to discover different means for developing reciprocal arrangements with their STEM counterparts.

Moreover, Siew, Amir and Chong (2015) examined 25 preservice and 21 in-service Malaysian science teachers' perceptions in implementing project-based STEM approach in science teaching. The researcher adopted the mixed method approach to gather qualitative and quantitative data from the sample before and after their participation in a two-day professional development program that exposed teachers to a STEM-PBL approach in teaching science. Instruments included surveys, interviews, open-ended questions, and classroom discussion. Results revealed that STEM professional development workshops had a great impact on raising teachers' perceptions. In addition, the professional development provided better understanding of the required support needed to improve teachers' implementation of effective project-based STEM approaches in teaching science at their schools. Moreover, there is a necessity for developing more STEM-based training programs, which attempted to target planning, instruction, content of STEM, assessment and higher thinking skills. Final recommendation proposed participation of all education stakeholders, teachers, Ministry of Education, STEM-related agencies, universities, experts and scholars in the journey of producing STEM-competent students.

In similar vein, Smith, Rayfield and McKim (2015) investigated in a more specialized branch of science. They investigated agriculture teachers' perceptions of and assessed their confidence in integrating STEM main domain in agricultural courses, in conjunction with their perceptions and implementation of STEM integration instructional methods. Stratified random sample of 280 teachers representing the American Associations for Agriculture Education regions. Self-reported online survey was used to collect quantitative data from participants. Findings showed that teachers had high perception for the four domain areas of STEM. Moreover, they have high confidence levels upon integrating both science and mathematics, while showed lower confidence regarding technology and engineering. Furthermore, differences were reported between gender, confidence integrating engineering, and perceptions regarding instructional method effectiveness. Main recommendation focused on further investigation for integrated STEM instructional methods from stakeholders. In addition to further examination of different ways to increase teachers' confidence in using effective instructional methods for STEM concepts.

In similar context, in 2016 Park, Byun, Han & Baek adopted descriptive method to investigate perceptions and practices of STEAM teachers (science, technology, engineering, arts, and mathematics) in South Korea. The researchers used a survey for STEAM teachers in model schools. Data analysis reported that the mainstream of Korean teachers had a positive view regarding STEAM education role, especially teachers with higher experience and male teachers. Additionally, Korean teachers emphasized different challenges upon implementing STEAM education, as the challenge of having enough sufficient time for effective implementation of STEAM lessons, increasing workloads, and lack of both financial and administrative support. The findings of the study emphasized the importance of providing adequate governmental support, the renovation of national curriculum, and the need of changes of the national assessment system for supporting STEAM education.

In a similar vein, Altan and Ercan (2016) conducted a qualitative study to examine the impact of professional development program on science teacher's perceptions and competences of STEM education in Turkey. Questionnaire was used to collect data from 24 science teachers, in addition to data from STEM lesson plans developed by teachers throughout the professional development training. Outcomes showed that there is a positive impact of this training program on perceptions of science teachers. Moreover, participated teachers raised suggestions related to (engineering) design-based science instruction for better adaption of STEM education. Implications suggested developing more professional development programs to raise awareness and highlighted the importance of STEM education, in addition to the need of strengthening teacher's skills in planning, implementing and evaluating the instructional process.

As for Srikoom, Hanuscin and Faikhamta (2017), the study examined in service teachers' perceptions towards implementing STEM in Thailand. Sample included 154 in service teachers randomly selected from both STEM – related and non-STEM related subject from all the schools in Thailand. Quantitative data was collected using questionnaire stemmed on perceptions of both STEM education and STEM integration. The collected data was analyzed using descriptive analysis, while the open-ended responses, was analyzed using content analysis. Results reported that 85.5% of the teachers never heard about SETM education, 19% cannot define STEM education, and 20.5% recognize STEM as a transdisciplinary program. Most of the teachers thought that STEM is a very interesting teaching approach. The vast majority of in-service teachers have big concerns regarding engineering discipline.

The study of Herro & Quigley (2017) examined teachers' perceptions and practices of STEAM. The sample of the study included 21 teachers from science and mathematics staff from southeastern middle school in the United States, who were enrolled in STEAM professional development program. The researcher used case study methodology to comprehend and compare both teachers' perceptions and practices prior to and after implementing professional development program. Results showed that there is development in teachers understanding of STEAM. The implemented professional development program was an effective primary stage to improve practices highlighting the importance of collaboration and integrating technology. Further implications from the study suggest high consideration towards developing more effective STEAM professional development programs to improve STEAM practices.

In a phenomenography study for Akran, Aşiroğlu (2018) aimed to investigate teacher's perceptions towards STEM education and the constructivist approach. The sample of the study included 40 primary school teachers, 30 mathematics teachers, 20 science teachers and 15 information technology teachers. Semi- instructed interviews were used to collect data. Both descriptive and content analysis methods were used. Conclusion indicated that both mathematics and science teachers have positive perceptions for STEM education, while primary teachers have some positive and some negative perceptions on different aspects of t STEM education. In contrary, information technologies teachers have negative perceptions.

Likewise, Nugroho, Permanasari and Firman (2019) surveyed 117 science teachers from Indonesia to examine their perceptions of STEM education. They used questionnaire as the main instrument for collecting quantitative data regarding teacher's perceptions, their understanding of STEM education and the established 21st century skills implementation. Interpretive methods were used for the analysis of teacher's responses. Results reported that science teachers clearly understand STEM education and that there is a significant need to focus on teachers practices and enhance it. Moreover, findings suggested that considerable attention is needed towards enhancing and raising both government and teachers awareness level regarding STEM education.

Moreover, Margot and Kettler (2019) attempted to understand teachers' perception of STEM integration and education by investigating the existing literature. They used 25 empirical articles that are compatible with the research questions and published the results in a scholarly journal in English from 2000 to 2016. Participants encompassed pre K – 12 teachers. Thematic analysis method was used to construct themes from data. Results highlighted that: the majority of teachers value STEM education, there are challenges that might hinder its implementation including pedagogical, curriculum, structural challenges, in addition to their major concerns regarding the students and assessments, and the insufficient support for teachers. Moreover, teachers identified the factors that would support their implementation of STEM education such as peer collaboration, appropriate curriculum, and support from district, previous experience and effective professional development programs. The vast majority of recommendations for improving practices of in-service teachers' instructions for STEM approach and for district support in providing opportunity time for peer teachers' collaboration.

In similar context, Nam, Quang, Hien, Bien, Trang, Minh, Ngan (2019) reported the transformative perceptions of Vietnamese in service (science, math, information technology and technology) teachers towards STEM education in secondary schools. The sample of the study included 150 teachers from 11 provinces of Vietnam that participated in teacher professional development program. They used survey to assess their perceptions towards STEM education before and after attending the teachers' development program. Findings from analysis using SPSS, pointed out the positive effectiveness of the program on teacher's perceptions towards STEM education. Recommendations emphasized on implementation of similar courses design.

Finally, Khuyen et al., (2020) aimed to explore Vietnamese teachers' perceptions to support STEM education development in three main domains: STEM education, STEM competencies, and challenges in STEM implementation. They used survey method to collect quantitative data from 186 STEM and non- STEM subfield teacher's. They used one way ANOVA to examine teacher's perception differences in term of educational background, teaching experiences, and their teaching subjects. The results presented that majority of teachers had constructive perceptions of STEM education. Moreover, a high significant difference in teachers' perceptions was attributed for the highest educational background and science specialty. While the least experienced teachers' have more positive view of STEM, in means of better understanding of STEM nature and evaluating STEM related competencies. Finally, they reported significant difference in attribution to educational background, in favor for the highest in relation to the three domains, while there is no significant differences in challenges among teacher's experience groups. Their recommendation was to use these results information in deigning effective professional development programs that can sustain STEM education in Vietnam.

2.3 Studies in Qatari Context

Although considerable research has been devoted to investigate science teachers' perceptions towards STEM education, to the best of the researchers' knowledge, only one study addressed teachers' viewpoints towards STEM education in Qatar. Quite recently, Ashour (2020) examined teacher's implementation of STEM curriculum in public kindergartens in Qatar. Moreover, the researcher investigated their viewpoints regarding the impact of STEM education on children, teachers and the educational process. She used multiple instruments such as classroom observation, interviews and a questionnaire to collect both qualitative and quantitative data. Results pointed out that there is a low degree of STEM implementation in kindergarten. In addition, STEM education has high degree impact on the child and the educational process while it has medium effect on teachers from teacher's viewpoints. The study concluded that teachers have positive constructive viewpoints concerning the impact of STEM education on children, teachers and educational process despite the fact that they do not implement it in a convenient level. Recommendations highlighted the important role of stakeholders at the MOEHE in providing more attention and support to STEM education. Furthermore, the need for more professional development programs to enrich teachers' capacities for further implementation of STEM through their curriculum.

2.4 Concluding Remarks

The researcher was keen to choose various former studies to provide more aspects that can help upon conducting the current study and give a different perspective to the discussion of current study results. The display of studies is from older to newer to show the development of teachers' perceptions towards STEM among years in different regions.

Although most of the previous studies aimed to examine science teachers' perception towards STEM education, El-Deghaidy and Mansour (2015) as well intended to identify the factors that facilitate or hamper STEM implementation in schools. Additionally, some studies examined the statistical significance of different variables on teacher's perceptions such as teaching experience, educational background, specialty and gender as per (Al Anzi & Al Gabr,2017; Al Aitebey, 2018; Al Salamat, 2019). Furthermore, other studies examined the beliefs and practices in addition to perceptions such as in (Wang, 2011; Park et al., 2016; Herro & Quigley, 2017). In addition, the target of (Wang, 2011; Nadelson et al., 2013; Atlan & Ercan, 2016; Herro & Quigley, 2017) was to measure and identify the impact of STEM professional development on teacher's perceptions and practices.

All the previous studies showed presence of variations in teacher's perceptions towards STEM education among different countries. As it showed positive perception towards STEM as in (Khuyen et al., 2020; Margot &Kettler, 2019; Arkan & Asiroglu,

2018) However, there was an evidence of a lower level of understanding STEM as indicated in (Srikoom et al., 2017; Brown et al., 2011). In addition, Bell (2016) pointed out that teacher's perceptions depend on their personal understanding of knowledge related to the efficiency of STEM practices. It was also mentioned in El-Deghaidy & Mansour (2015) that the teachers' perceptions had great influence on the implementation of STEM in classes. Moreover, findings showed significant positive impact of various STEM professional development programs on changing teachers' perception and practices as per (Nadelson et al., 2013; Siew, Amir, Chong, 2015; Altan& Ercan, 2016; Herro & Quigley, 2017, Nam et al., 2020). Furthermore, some studies related the difference of perception to different variables such as gender in (Al Aitebey, 2018; Smith, Rayfield & Mckin, 2015; Park et al., 2016), and to teacher's specialty as per (Al Atibey, 2018). Whereas (Al Anzi & Al Gabr, 2017) relate the statistical significance differences to the teaching grade level, while (Al Salamat, 2019; Park et al, 2016; Khuyen et al., 2020) associated the statistical significance to teaching educational background, where the highest significant attributed to highest educational background. Finally, some studies showed no significant difference in perceptions among variables, such as specialty in (Al Salamat, 2019) and different teaching experiences as in (Khuyen et al., 2020; Al Anzi & Al Gabr, 2017).

The studies showed a variation upon using different approaches, methodologies and instruments. Descriptive methodology was common in the majority of the studies, as it is the most compatible approach with the studies related to perceptions, beliefs and attitudes (Creswell et al., 2003). However, Al Basha (2018) preferred the explanatory design, Madani & Forawi (2019) undergo parallel mixed methods, while Wnag (2011); Herro & Quigley (2017) used case study. On the contrary, Nadelson et al. (2013) and Nam et al. (2020) used the experimental design for adequate investigation of the impact of STEM professional development programs on teachers' perception. Moreover, (Bell, 2016; Arkan and Asiroglu, 2018) used phenomenography approach to describe different teachers' perceptions and their understanding of STEM education. Finally, Margot & Kettler (2019) had different remarkable approach by examining the existing literature of teachers' perceptions towards STEM education.

Literally, all the studies conducted in MENA region, and majority of other studies conducted in other regions used the questionnaires and surveys to collect either quantitative or qualitative data. However, some of them used semi – structured interviews, focus group interviews, teacher reflection , classroom observations and document analysis to collect qualitative data as in (El-Deghaidy & Mansour, 2015; Madani, 2020; Bell, 2016). Furthermore, some of them used multiple instruments to collect both qualitative and quantitative data to provide thorough explanation for the results later as in (Al Basha ,2018; Madani & forawi ,2019; Wang, 2011; Siew, Amir & Chong,2015; Srikoom, Hanuscin & Fakhmata, 2017; Arkan &Asiroglu ,2018; Ashour, 2020).

In the light of the former studies, the current research paper has benefited from previous studies; mainly within the theoretical framework, and identifying how to build and develop instruments to examine perceptions of teachers towards STEM. In consistency with the availability of numerous descriptive studies on science teachers' perceptions towards STEM education in all regions, the current research study is descriptive in nature except for using explanatory sequential mixed method design. The current study agreed with (Al Basha,2018; Madani &Forawi, 2019; Wang, 2011; Siew, Amir, Chong, 2015; Srikoom, Hanuscin & Fakhmata, 2017; Arkan &Asiroglu, 2018.) upon using mixed data. Furthermore, it agrees with Al Basha (2018) upon using the explanatory design. Moreover, the current study relied on the use of the survey for quantitative data collection as in majority of the previous listed studies to measure the perceptions of the sample towards STEM education. Afterwards, the focus group interview was used to collect qualitative data as in El-Deghaidy & Mansour (2015) to deepen the understanding of primary science teachers' perceptions in Qatar.

Although there are many published studies on science teachers' perception in different regions, most of the studies published in MENA region were conducted on KSA teachers' perceptions except for AL Basha (2018) which was conducted in UAE, and Elayyan and Al- Shizawi (2019) in Sultanate of Oman. Accordingly, – to the Researcher's knowledge–, there is still an urgent need for more research work on this topic using different approaches in the Arab world in general and in Qatar in particular. Based on concluding remarks, the position of the current study is clearly recognized among the previous studies. Thus, this promotes the researcher to work and research in this field.

Chapter Three: Research Methodology

The current chapter aims at introducing the research approach to investigate the perceptions of primary science teachers towards STEM education and identify the challenges of its implementation in public schools in the state of Qatar. Moreover, this chapter will include the research design, population, sampling, pilot studies and ethical considerations

3.1 Research Design

The current research design applies descriptive methodology. Precisely, an explanatory sequential mixed method approach. This design is composed of two distinguishable phases; quantitative (QUAN) followed by qualitative (QUAL) (Creswell et al., 2003). The first phase focuses on the data collection and analysis of the quantitative input to reach a generic understanding to the research questions. Subsequently, the second phase expands to analyze the collected qualitative data, which explores in depth the respondents' views on the results of the statistical quantitative data. Thus, results of both phases are complementary to each other (Rossman and Wilson, 1985; Tashakkori and Teddlie 1998; Creswell 2003). Moreover, the applied approach elucidates the quantitative results with a certain level of abnormality (Creswell, Goodchild, and Turner 1996; Green and Caracelli 1997; Creswell, 2005; Moghaddam, Walker, and Harre 2003). Furthermore, the consolidation of applying both quantitative and qualitative methods assists the researcher in establishing a comprehensive database on the topic under study (Teddlie & Yu, 2007).

In the current study, the first part of the research is the survey that aims to collect quantitative data about the perceptions of science teachers towards STEM education and challenges facing its implementation in primary public schools in the state of Qatar.

The second part is collecting qualitative data using the focus group interviews to provide further explanation to the questionnaire results.

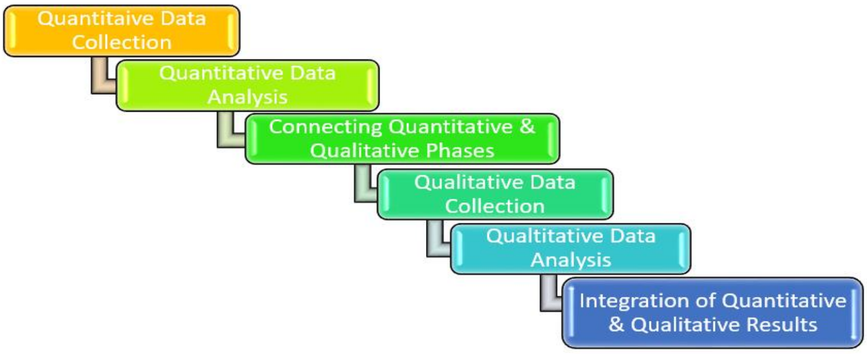

Figure (9): Explanatory sequential mixed method design

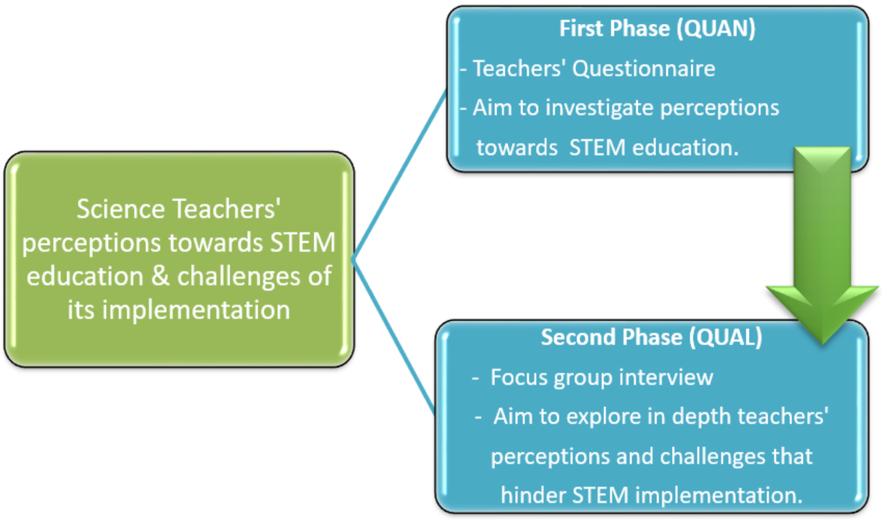

Figure (10): Design of the research method and data collection

3.2 Research Context and Respondents

3.2.1 Targeted Population

The current study targets science teachers working in public primary schools of Qatar during the academic year 2020-2021. The logic behind the selection of this targeted population; is the limitation in the availability of studies covering the topic of STEM education in public primary schools in Qatar, despite the fact that the number of primary schools represent around 37% of total public primary schools in Qatar (Appendix 1) (Planning and Statistics Authority, 2019). Moreover, according to the latest MOEHE records for the current academic year (2020-2021), there are (412) science teaches on the job within public primary schools in the state of Qatar (Teachers Affairs Office, November 24, 2020). Those teachers represent 6.15% of total number of teachers in public primary schools (Appendix 1) (Planning and Statistics Authority, 2019). Furthermore, the current population of science teachers includes (135) male science teachers and (277) female science teachers, which represents respectively 32.7% and 67.3% of the targeted population (Teachers Affairs Office, November 24, 2020).

3.2.2 Sampling Strategy

In sequential mixed method approach, the researcher targeted two samples mainly. For collecting the quantitative data (QUAN), the researcher targeted the whole population to collect as many responses as possible from science teachers in public primary schools through a web-based survey (Sample 1).

The researcher sent the web- based survey to all the public primary schools in the state of Qatar with an invitation for the science teachers in their schools to respond to the questionnaire. In addition, the web-based survey was also shared via social media application (WhatsApp) to science teacher’s groups; in order to gather as many responses as possible. The survey was open from 16th of December 2020 till 14th of February 2021. The researcher received (148) responses, which represents approximately 36% of total science teachers in public primary schools in Qatar. This percentage provided greater reliability for the study and this may allow the researcher to generalize the results (Cohen, Manion & Morrison, 2011).

Hence, in QUAN-QUAL studies both the methodology and results from QUAN phase influence the sampling methodology consequently employed in the QUAL phase (Teddlie & Yu, 2007). Thus, after statistical analysis of questionnaire, quantitative data was interpreted and classified. Subsequently, purposive sampling technique used in qualitative data collection (QUAL). Purposive sampling yields to deepen the information on the addressed topic, using a small number of cautiously selected participants (Teddlie & Yu, 2007).

The researcher selected the members of the four focus groups (Sample 2) from respondents of survey (Sample 1) based on two criteria: receiving STEM related professional development training and teaching experience ranging from six to fifteen years or more. The researcher assigned five science teachers for each focus group. It is remarkable that the selected science teachers for sample 2 are former participants in the QUEMTA program (Qatar University Exxon Mobil Teaching Academy) implemented by NCED (National Center for Educational Development) in the academic year 2019 - 2020. QUEMTA program includes STEM education as one of the main courses to be covered and is achieved through the training programs (National Center for educational development, 2020).

3.2.3 Survey Respondents

The number of survey respondents (Sample 1) was 148 science teachers, which represents approximately 36 % of the total number of science teachers in public primary schools in the state of Qatar. The demographic data of the respondents is included in the first section of the questionnaire (Appendix 2). The demographic data included the gender, teaching experience, educational background, highest degree obtained, country of highest degree obtained, specialty, school location, in addition to detailed information on weather STEM training was received and STEM lessons were taught or not and how STEM is being taught in their school. Demographic data of the respondents was analyzed using descriptive statistical analysis as shown in Table (1).

Table (1): Descriptive statistical analysis of demographic data.

	Demographics	Frequency	Percentage
Gender	Male	18	12.2%
	Female	130	87.8%
Educational Background	Bachelor	117	79.1%
	Higher Diploma	11	7.4%
	Master degree	19	12.8%
	Doctoral	1	0.7%
Country of highest degree	Qatar	70	47.3%
	Others	78	52.7%
Teaching Background	Less than 5 years	17	11.5 %
	6 to 10 years	43	29.1 %
	11 to 15 years	50	33.8 %
	More than 16 years	38	25.7 %
Specialty	Biology	39	26.4 %
	Chemistry	42	28.4 %
	Physics	16	10.8 %
	Geology	7	4.7 %
	Others	44	29.7 %
School location	Doha	77	52 %
	Al Rayyan	34	23 %
	Umm Slal	10	6.8 %
	Al Khor & Dhekra	3	2 %
	Al Wakrah	7	4.7 %
	Al Shamal	7	4.7 %
	Al Sheehaniya	8	5.4 %
	Al Daayen	2	1.4 %

	Demographics	Frequency	Percentage
Have you ever received any STEM related professional development training?	Yes	60	40.5 %
	No	88	59.5 %
Have you ever taught STEM lesson?	Yes	53	35.8
	No	95	64.2
How is STEM being taught/offered in your school?	Extracurricular activity	119	80.4 %
	After school program	13	8.8 %
	Regular curriculum	16	10.8 %

The above table (1) shows that the respondents included (18) male teachers (12.2 %) and 130 female teachers (87.8 %). Majority of science teachers hold a bachelor's degree (79.1%), while (7.4%) hold a higher diploma, (12.5%) hold master degree and only one teachers hold doctoral degree (0.7%). (47%) of the respondents got their highest degree from Qatar while (53%) got it from another countries.

In terms of teaching experience, (33.8%) of the sample respondents have teaching experience from 11 to 15 years, (29.1%) of the sample have experience from 5 to 10 years, (25.7%) of them have teaching experience 16 years or more and (11.5 %) of the sample have less than 5 years teaching experience.

In relation to specialty, the sampled respondents is (28.4%) Chemistry, (26.4%) Biology, (10.8%) physics, (4.7%) Geology and (29.7%) mentioned other specialty such as Mathematics, Statistics, Biomedical, and Engineering. In respect to respondents' school location, (52%) of respondents were from schools in Doha, followed by (23%) in Al Rayyan, (6.8%) in Umm Salal, (5.4%) in Al Shaniya, (4.7%) in Al Wakrah and

Al Shamal, while the minimum percentage was from Al Khor (2%) and Al Daayen with (1.4%).

Moreover, (40.5%) of the respondents stated, that they received STEM professional development training, while (59.5%) did not receive. Accordingly, (36%) of the respondents taught STEM lessons while (64%) did not. Finally, the majority of the respondents (80.4%) stated that STEM is being presented in their schools as extracurricular activity, while (8.8 %) of responses as after school program , while (10.8%) only reported that it is taught within the lessons of the regular curriculum.

3.2.4 Focus group respondents

In addition to their years of experience (6 to 15 years or more) of teaching in Qatar public schools, the focus group interviewees (Sample 2) were selected based on their receipt of STEM related professional development program such as QUEMTA or any other STEM related training. Sample (2) as shown in table (2) included four focus groups, each group consists of three teachers. The teachers are from different school locations. Those teachers are knowledgeable on the focus topic of the study, its practices and challenges that might hinder its implementation in in public primary schools.

Table (2) Demographic characteristics of focus groups respondents

Focus Group number	Teacher code	Gender	Teaching experience	School location
1	F1	Female	6 years	Al Obaib
	F2	Female	6 years	Al Hilal
	F3	Female	12 years	Al Siyliah
2	H4	Female	7 years	Zeikreit
	H5	Female	15 years	Um Slal
	H6	Female	10 years	Doha

Focus Group number	Teacher code	Gender	Teaching experience	School location
3	M7	Male	11 years	Mauither
	M8	Male	17 years	Al Dafna
	M9	Male	14 years	Um Slal Ali
4	I10	Female	13 years	Um Slal Mohamed
	I11	Female	18 years	Al Azyzia
	I12	Female	9 years	Old Airport

3.3 Research instruments

In the current study, two main instruments were employed for collecting data; a web-based survey and focus group interviews. In reference to "Research Methods in Education" for Louis Cohen, Lawrence Manion, Keith Morrison, the main privilege of using different instruments is to enrich the focus study with more reliable data (broader and deeper) than a single instrument would yield.

3.3.1 Teacher's Survey

Survey is a common tool that offers benefits of standardized and open responses to a variety of topics for a large sample or population. More than that, other common advantageous aspects of surveys are their low cost, high-reliability and validity, quickness and practicality in completion (Cohen et al., 2018). Thus, an online survey (consisting of two sections) was created to collect quantitative data.

- Section 1: This section enclosed nine items including demographic data such as gender, teaching experience, educational background, country of highest degree, major, school location, in addition to the STEM training received, STEM teaching experience and how STEM is being taught in their school.

- Section 2: This section comprised 42 items classified into four main domains. The study domains comprised of a scale ranging from one to five, where (1) reflected an opinion of “strongly disagree” and (5) is “strongly agree”. The items adopted and modified from various studies in multiple countries. Items number (15, 16, 17, 19, 20, 24, 25, 26, 27,28,29,30, 32 & 33) adopted from Al Anzi & Al Gabr (2017) in the Kingdom of Saudi Arabia (KSA), while items (10, 12, 13, 14, 35, 36, 37, 38, 39, 43, 44, 45, 46, 47,) are from Khuyen et al. (2020) in Vietnam. Additionally, items (11, 18, 31, 34, 41, and 42) adopted from Al Basha (2018) in the United Arab Emirates (UAE), while the items (21, 22, 23, 48, 49, and 50) constructed by the researcher stemmed on reviewed literature and the current theoretical framework. All items were adjusted appropriately for context in Qatari public schools.

The first domain: Teachers’ perceptions about STEM education’s knowledge. It consists of fourteen items (10- 23). These are designed to examine teachers’ perceptions about STEM characteristics features, main concepts and its instructional practices.

The second domain: Teachers’ perceptions towards STEM teaching requirements. It included eleven items (from 24 -34). These items examine teachers’ perceptions of STEM implementation requirements in science classes.

The third domain: Teachers’ perceptions of the impact of STEM education on students’ outcomes. This domain consists of eight items from (35 – 42), these items examine perceptions’ of science teachers of the impact of STEM education on enhancing 21st century skills such as critical thinking, problem solving and decision making, in addition to measuring the impact of STEM education on students’ learning outcomes.

The fourth domain: Teachers' perceptions about the challenges facing STEM implementation. This domain included the last eight items. Seven of these items are closed statements from (43 -50) describing and examining the challenges that might hinder STEM implementation in science classes. The last item (51) is an open ended question about further challenges that might face teachers and hinder STEM implementation in their science classes.

3.3.1.1 Teacher's Survey Validity and Reliability

Validity and reliability are two crucial factors to demonstrate and communicate the consistency of the research processes and trustworthiness of the findings (Creswell, 2014).

Validity:

Validity of the instrument guarantees that the targeted instrument is measuring comprehensively the required variables and domains (Cohen et al., 2018). To declare the content of the survey, the survey was checked by five university professors from Qatar University, American University in Cairo and Exeter University, in addition to four professional development specialists (Math & Science specialty) from the National Center for Educational Development in Qatar University. They all recommended some modifications regarding the language and to test one idea or concept within each item. Further modification was applied to the survey accordingly to the feedback and recommendations.

Moreover, Constructed validity was tested using confirmatory factor analysis as shown in table (3). It determines the interrelationships between variables to specify if those variables can be gathered into a smaller set of underlying factors.

Table (3): Confirmatory Factor analysis

	First domain	Second domain	Third domain	Fourth domain	Communalities
1	0.777				0.603
2	0.787				0.620
3	0.733				0.537
4	0.792				0.628
5	0.798				0.637
6	0.886				0.786
7	0.881				0.776
8	0.890				0.792
9	0.863				0.746
10	0.819				0.671
11	0.861				0.741
12	0.898				0.806
13	0.875				0.766
14	0.873				0.761
15		0.748			0.559
16		0.875			0.766
17		0.897			0.804
18		0.779			0.606
19		0.902			0.813
20		0.926			0.858
21		0.902			0.814
22		0.922			0.850
23		0.930			0.865
24		0.865			0.749
25		0.889			0.790
26			0.895		0.800
27			0.914		0.836
28			0.907		0.823
29			0.912		0.832
30			0.858		0.735
31			0.785		0.616
32			0.908		0.824
33			0.907		0.823
34				0.802	0.643
35				0.757	0.573
36				0.808	0.654
37				0.733	0.538
38				0.618	0.582
39				0.802	0.644
40				0.722	0.521
41				0.710	0.504

Table (3) shows that all the communalities values for all components are greater than (0.5), which indicate high validity of these items. Additionally, all values of loadings are greater than (0.5) which point out high correlation between these questions (Keller & Warrack, 1999).

Reliability:

The reliability of the instrument guarantees the consistency of the measurement per time (Cohen et al., 2018). The internal consistency coefficient (Cronbach's Alpha) reflects the reliability of a questionnaire. As per Cohen et al. (2018) whenever the value of the Cronbach's alpha increases; the internal reliability becomes stronger. Cronbach's Alpha values ranged from (0.883) to (0.960), which indicate high internal reliability between the questionnaire items and between the items within each domain as shown in table (4) (Cohen et al., 2018).

Table (4): Cronbach's alpha to measure reliability for research domains

Indicator	Cronbach's Alpha
Teachers' perceptions of STEM education knowledge.	0.966
Teachers' perceptions of STEM teaching requirements.	0.969
Teachers' perceptions of the impact of STEM education on students' outcomes.	0.960
Teachers' perceptions of the challenges facing STEM implementation.	0.883

3.3.2 Teachers' Focus groups Interview

Teachers' focus group interviews is the second phase of this study to collect the qualitative data. As indicated in Cohen et al. (2018), the dynamics of how participants were interacting in the focus group is significant as it leads to a collective view on the topic under study. The focus group protocol was adopted from El-Deghaidy & Mansour

(2015) focus group interview. The final form of the focus group questions was developed after conducting, analyzing and interpreting the survey (Appendix 4). The focus group questions aim to deepen the exploration of science teachers' familiarity and perceptions regarding STEM implementation and identify the main factors that will hinder its implementation in science classes in public primary schools. A total number of four focus groups interviews (N=4), in which each group consists of three participants accepted to be interviewed. All the participants that agreed to be interviewed received a consent form to be signed and returned back via email.

3.4 Research Procedures

This study was executed at public primary schools in Qatar during academic year 2020 - 2021. Prior the study implementation, the researcher obtained clearance from MOEHE (Appendix 3), in addition to the clearance from the Review Board Department at Qatar University (Appendix 4).

This approval required filling QU-IRB application and checklist forms in addition to attaching all the required documents (MOEHE approval, IRB supervisor letter, the instruments (survey and focus group interview), and two consent forms for both instruments and the proposal of the study. All the previously listed documents and forms were sent via email to Qatar University Review Board. Succeeding, the ethical approval was sent from QU- IRB department after reviewing all the requirements and forms (Appendix 4).

Subsequently, the researcher started the first phase of the study by constructing the web-based survey using Jotform application. Furthermore, the researcher prepared an invitation message to be sent via WhatsApp messages, which include the title, purpose, approval from MOEHE and QU-IRB, the online survey link and consent statement on voluntary participation in this study. Moreover, the researcher prepared an invitation email for all the public primary schools in Qatar, including the same main information mentioned in the previous invitation message. A total number of 148 primary science teachers responded to the web-based survey on a voluntary basis.

Prior to initiating the second phase and implementing the focus group interviews, the data of the survey was statistically analyzed and interpreted. Based on its results, the focus group interview questions were modified. Then, the researcher contacted the participants of the focus group to set their appropriate time for the interview and sent them the consent form to sign it and send it back via email. The focus groups interviews were implemented and recorded using Zoom and Microsoft teams' application. Each focus group interview lasted from 30 -45 minutes approximately. The researcher followed the focus group protocol, which had great impact on building positive relationship with participants, which led to authentic, natural response to all the interview questions (Creswell, 2014). Consequently, the focus group interview aided at collecting various data regarding teachers' perceptions towards STEM education and challenges of its implementation in science classes in more depth.

Finally, the researcher combined outcomes gained from both quantitative and qualitative analysis, to reach final comprehensive results that will allow providing recommendations to be taken into consideration in the near future by other researchers and stakeholders working in the academic field.

3.5 Data collection & Analysis

In this study, the research adopted the explanatory sequential mixed method approach, which includes collecting and analyzing of mixed data. The first stage of analysis was for the quantitative data collected using the web-based survey as mentioned previously. The researcher used different methods of statistical analysis while working on the generated data using the Statistical Package of the Social Sciences

(SPSS). A descriptive analysis was used for section one of the survey to describe the demographic data of the participants and in the four domains of section two to interpret the science teachers' perceptions. An inferential statistic T-test was executed to examine if there are any statistical significant differences in the primary science teachers' perceptions due to gender, teachers' educational background the received STEM professional development programs and STEM teaching experience. Moreover, ANOVA test was used to explore if there is variance between teachers' perceptions in any of the domains related to their different teaching experience. Furthermore, Cohen's D effect size is used to degree the correlation between variables.

The second stage of analysis was for focus group interviews, which has been digitally recorded, followed by a transcript which formed the initial data source. The transcribed interviews facilitated the provision of summary patterns and themes. As a follow-up, the researcher used the thematic analysis method to recognize those themes and patterns in the qualitative data. The usage of thematic analysis is a popular scientific methodology that is being widely used in qualitative data analysis (Braun & Clarke, 2013).

Thematic analysis encompasses more than simply reporting what is included within the data; it provides prominent prospect revealing explanatory story about the collected data from research questions (Braun & Clarke, 2013). Braun and Clarke's (2013) embedded six phases for the thematic analysis process as follow:

- The first phase of thematic analysis is the commonly first phase of any qualitative analysis, which is the familiarization with the data and identifying the hypothetically important data interrelated to the research questions.
- The second phase is the systematic coding of the data that will result in generating the initial codes.

- In the third phase, the analysis shifts to an expansive focus across the coded data to search for themes. In this phase, there is ideal way to do it, researchers should rely on their analytic decision in answering the research, which will result in set of themes and relevant correlation between these themes.
- In the fourth phase, it is very vital to review the potential themes. Reviewing the potential theme takes place by checking the relevance of the themes to coded data and research questions. This phase ends in a final set of themes.
- Defining and naming themes where the researcher analyzes interpret and correlates between all the emerged themes. This is followed by naming the final themes.
- The last phase of thematic analysis is producing the report. This phase offers chance for refining the analysis, which includes the reordering of the themes and relating them to the literature.

3.6 Ethical Considerations

Ethical consideration is one of the prominent factors that should be anticipated upon conducting research (Creswell, 2014). In the current study, the researcher was keen on all the ethical considerations related to human rights for this purpose. Therefore, approvals from MOEHE (Ministry of Education and Higher Education) and QU-IRB were received before proceeding with the study (Appendix 4). Furthermore, the structure of the web-based survey starts with a consent form that provides all the required information regarding the study purpose, right to withdraw at any time without any consequences, the voluntary nature of participation, privacy and confidentiality statements and contact information of the researcher and supervisor for any further clarifications or questions. Moreover, the consent form included a statement that articulates that by filling in this survey, the participant is in agreement and approves all items of the consent form.

Moreover, consent forms for the focus groups interview were sent via email to the participants to be signed and returned back to the researcher. The consent form includes the study objective, and that interviewees do have the right to withdraw from the exercise without holding any responsibilities or bearing any consequences. The consent form also includes content related to privacy & confidentiality statements, permission for recording the interview, contact information of both the researcher and supervisor for any further clarification or questions.

Furthermore, in order to reassure more truthfulness, the survey and the focus group interviews were anonymous for the sake of confidentiality and all shared information was used for the research purpose only. All the previous factors had positive secure feelings for the participants, which enhanced them to share their perceptions and practices (Creswell, 2014).

Chapter Four: Findings and Results

The current study targeted to investigate primary science teachers' perceptions towards STEM education in primary public schools in Qatar. This chapter reports the results of conducting explanatory sequential mixed methods approaches; the quantitative phase comprises teachers' questionnaire followed by the qualitative phase that comprises focus groups interviews.

This chapter enclosed two main sections, purposefully to respond to the raised research questions. The first section presents teacher's perception towards STEM education from four main domains that reflects the four sub-questions. The second section presents the significant variances, if any, for gender, educational background, teaching experience, the received STEM professional development programs, STEM teaching experience on teachers' perceptions.

Section One: Teachers' perceptions towards STEM education.

This section includes four main domains mirroring the sub- questions of the study. The first domain is teachers' perceptions related to their knowledge of STEM education, the second is teachers' perceptions of STEM teaching requirements, and the third domain focus on teachers' perceptions on the impact of STEM education on students' outcomes, while the last domain is teachers' perception on challenges facing STEM implementation in Qatari primary public schools.

In the description of teachers' perceptions towards STEM education, the researcher used the means and standard deviation of 148 teachers' responses. To interpret the perceptions' level, the researcher classified the means into three levels as shown in table (5). This was done by computing the difference between the highest and the lowest point (5-1=4), then dividing the range by three (4÷3= 1.33). The below table (5) show the items in descending order.

Table (5) Perceptions' level according to the means

Weighted Average	Result interpretation
1 - 2.33	Low
2.34 - 3.67	Moderate
3.68 - 5	High

4.1 What are science teachers' perceptions towards STEM education in public primary schools in Qatar?

Generally, the descriptive statistics comparison of the four domains (Table 6) shows that means for all domains is around (4) which means that teachers' perceptions is high in the four domains. Teachers' perceptions of STEM teaching requirements showed the highest mean of (M= 4.12) and a standard deviation of (SD= 0.61). Conversely, Teachers' perceptions on challenges facing STEM implementation recorded the lowest with a mean of (M= 3.99) and a standard deviation of (SD= 0.60). Whereas teachers' perceptions of Impact on students outcomes and their perceptions' of STEM knowledge gained mean values of (4.10) and (4.08), with standard deviation of (0.62) and (0.64) respectively.

Table (6) Descriptive statistics comparison of the four domains

Domains	Min	Max	Mean	S.D.
Teachers' perceptions of knowledge about STEM education.	2	5	4.08	0.64
Teachers' perceptions of STEM teaching requirements.	2	5	4.12	0.61
Teachers' perceptions of the impact of STEM education on students' outcomes.	2	5	4.10	0.62
Teachers' perceptions of the challenges facing STEM implementation.	1.875	5	3.99	0.60

4.1.1 Teachers' perceptions of STEM education knowledge.

Sub-question 1: What are the science teachers' perceptions of STEM education knowledge in Qatari public primary schools?

4.1.1.1 Quantitative Results (Survey)

The first domain of the survey covers fourteen statements related to STEM education knowledge. Findings illustrated in table (7) show that the overall teachers' perceptions of STEM education knowledge is high with an overall mean value (4.08) and standard deviation of (0.64). Interestingly, the two statements "STEM enhances students' thinking to generate innovative solutions to real life problems" and "Problem based learning is an important element in teaching STEM" got the highest mean with value (4.18) and standards deviation of (0.75), (0.73) respectively. On the contrary, the statement related to the ability of teachers to combine optionally any of STEM domains content knowledge in the current curriculum to create STEM lessons got the lowest mean with value of (3.87) and highest standard deviation of (0.89).

Table (7) Descriptive Statistics of Teachers' perceptions of STEM education knowledge.

Statement	Min	Max	Mean	S.D.
The concept of STEM education is defined as teaching the knowledge, skills, and logical thinking related to STEM careers.	1	5	4.02	0.81
STEM education is a connection between subjects within authentic context to enhance students' learning.	1	5	4.08	0.85
Teachers can *optionally* combine science, technology, engineering, and mathematics knowledge in the current curriculum to create STEM lessons.	1	5	3.87	0.89

Statement	Min	Max	Mean	S.D.
The term “technology” in STEM is *NOT* solely restricted to the use of technological tools in the classroom, such as computers, projects, and cameras.	2	5	3.99	0.83
STEM helps in connecting scientific concepts and knowledge in an interdisciplinary paradigm.	2	5	4.00	0.73
STEM helps students build scientific explanations and evaluate solutions.	2	5	4.16	0.74
STEM enhances students’ thinking to generate innovative solutions to real life problems.	2	5	4.18	0.75
Problem based learning is an important element in teaching STEM	2	5	4.18	0.73
STEM aims at linking knowledge to global problems such as global warming and saving energy.	2	5	4.13	0.79
STEM allows the diversity of educational context through multiplicity of educational outcomes.	2	5	4.05	0.74
STEM employs a variety of strategies to solve scientific problems with flexibility.	2	5	4.10	0.72
STEM removes barriers between subjects and provides flexibility upon integrating new information.	2	5	4.14	0.70
STEM allows using different methods and approaches to achieve tasks.	2	5	4.13	0.71
The term “technology” in STEM is *NOT* solely restricted to the use of technological tools in the classroom, such as computers, projects, and cameras.	2	5	4.14	0.72
Total	2	5	4.08	0.64

4.1.1.2 Qualitative Results (focus groups’ interviews)

Findings in this section as shown in Table (4) are organized and reported in terms of variances and similarity patterns related to teachers’ perception of STEM education knowledge between focus groups. Thematic analysis of the groups’ answers, results into four main key findings: integrated disciplines of STEM, general characteristics of STEM education , the relation between teaching STEM and future careers, and instructional practices of teaching STEM.

Variance pattern appeared in the first key finding related to describing STEM education in relation to integrated disciplines. Each group had different description of STEM education in relation to their integrated disciplines. Two groups mentioned that "STEM encloses all the scientific disciplines and Arts", while others stated that "STEM is link between science and mathematical branches only", and they considered the science of engineering as geometry which is one branch of Mathematics, while another group did not mention the engineering at all.

The second key finding is related to general characteristics of STEM education. Mostly, all the respondent groups agreed that STEM is linked to real life where all the scientific concepts are applied to solve various real-life problems. They stated that STEM requires from students a high level of thinking skills to solve these real life problems, and these skills are acquired by practicing rather than teaching. This statement is directly aligned with their agreement that STEM aims at enhancing students' skills to use it in real life situations, which will in turn increase students' motivation to learning.

In the third key finding, there were variance in the respondents' answer to the relation between teaching STEM and future careers. Some groups stated that STEM enhances students' focus on future careers and jobs related to their projects. In addition, one group stated that it is an intention trend to enroll students in STEM schools to qualify them for specialized careers in the future. Conversely, some groups stated that STEM is not focusing on future careers or professions; yet sometimes it is just referring to them by coincidence and not with an intentional planning.

Finally, the last key finding described the instructional practices of STEM. Focus groups agreed that the main instructional practices of STEM include content integration of the four STEM disciplines, problem based learning, projects and inquiry based learning, 21st century skills, collaboration and teamwork, in addition to application of scientific concepts from different disciplines in real life situations.

Table (8): Teachers' perceptions of STEM education knowledge – Qualitative data

Pattern	Key findings	Quotation Examples
Variance	Teachers' knowledge of integrated disciplines of STEM education.	- "STEM is present in any inquiry or topic by linking science , math , engineering and technology, Technology is any tools such as measuring tools or computers during research, Problem solving in STEM include using numbers, data, calculations, using units, data analysis, and engineering design." - "STEM encloses all scientific disciplines and Arts; STEM is more about creativity and thinking rather than literacy and recalling information." - "STEM Link science information with different Mathematical branches to deepen theses information via engineering or mathematical calculations".
Similarity	General characteristics of STEM education.	- "STEM is linked to real life problems and several existing issues such as ethical, national and cultural issues". - "STEM is linked to real life problems by using problem solving for real life problems such as extinction of animals, global warming , pollution , all the solutions is developed by students, this highlight for students the importance of finding solutions for real life problems." - "STEM requires critical thinking, practical thinking and skills for linking science with real life in one complete big picture." - "Students acquire skills in STEM lessons by practicing not by teaching them." - "STEM enhances students' motivation for learning."
Variance	The relation between teaching STEM and future careers	- "Some students in grade 6 during their work in a project, they mentioned that they want to be astronauts or scientists, so they can find other alternative energy resources and find another planet that they can live in."

Pattern	Key findings	Quotation Examples
Similarity	STEM Instructional practices	- "STEM is a worldwide program, it is a trend adopted by the elites of the society. People, who aspire to educate their children at a high level, enroll their children in STEM Schools because it qualifies them for specialized jobs in the future." - "STEM is related to guide students to STEM field's careers, I read a report from Ministry of Commerce in USA, and they reported that job opportunities for those with specializations related to mathematics and science increased by 17%." - "STEM is not directing students to professions, but rather just refer to it, such as in discussing space, show that this specialty is important for the future, another example refer to importance of medical professions." - "Projects in STEM are not restricted to a specific subject but it integrates all subjects and life skills in the same project." - "Problem based learning is important in teaching STEM , students are more interested in solving problems they face or some of their relatives face in real life, even if they know the solution, they are interested to find a clear explanation for this solution." - "STEM encloses students' learning using project based learning and application." - "Problem based learning is one of the main instructions in teaching STEM, problems in general allow students to think in multi-dimensions and subject to solve it." - "STEM based on 21st century skills, collaboration and teamwork, students try to find solutions for real life problems, students think critically, students try to solve problems in real life using scientific method, integrating and linking between technology, mathematics and different domains of science."

4.1.2 Teachers' perceptions of STEM teaching requirements.

Sub-question 2: What are the science teachers' perceptions of STEM teaching requirements in Qatari public primary schools?

4.1.2.1 Quantitative Results (Survey)

In the second domain, there was eleven items specified for STEM teaching requirements. Findings demonstrated in table (9) show that the overall teachers' perceptions of STEM teaching requirements are high with an overall mean value (4.12) and standard deviation of (0.61). This means that in average, respondents tend to agree to these statements. The statement related to teaching STEM requires enhancing students' acquisition of communication skills, while handling STEM tasks scored the highest mean of value (4.20) and standard deviation of (0.67). However, the statement related to teaching STEM requires training students on engineering design; scored the lowest mean with value of (3.96) and highest standard deviation of (0.75).

Table (9): Descriptive Statistics of Teachers' perceptions of STEM teaching requirements.

Statements	Min	Max	Mean	S.D.
Teaching STEM requires employing mathematical operations in scientific topics.	2	5	4.01	0.71
Teaching STEM requires using inquiry-based learning.	2	5	4.18	0.67
Teaching STEM requires enhancing students' acquisition of communication skills while handling STEM tasks.	2	5	4.20	0.67
Teaching STEM requires training students on engineering design.	2	5	3.96	0.75
Teaching STEM requires engaging students in evidence-based discussion.	2	5	4.14	0.72
Teaching STEM requires raising curiosity about natural phenomena and scientific discoveries.	2	5	4.17	0.69
Teaching STEM requires integrating two or more of STEM fields within one lesson.	2	5	4.09	0.73
Teaching STEM requires training students to search and investigate using various reliable resources from different disciplines.	2	5	4.13	0.69
Teaching STEM requires enhancing students' abilities to solve problems and scientific thinking.	2	5	4.18	0.65
Teaching STEM requires using technology to integrate multiple STEM fields.	2	5	4.13	0.69
Teaching STEM requires making decisions based on data to understand how to refine ideas further.	2	5	4.12	0.67
Total	2	5	4.12	0.61

4.1.2.2 Qualitative Results (focus groups' interviews)

As shown in table (10), findings related to STEM teaching requirements are organized according to the similarities between them. Three main domains for STEM teaching requirements resulted from this structure; STEM teaching requirements for teachers, STEM teaching requirements for students and STEM teaching requirements related to stakeholders. The findings in the three domains showed notable similarities among groups.

Findings in the first domain represents STEM teaching requirements for teachers. All groups mentioned that teachers' awareness, beliefs, perceptions and attitudes of STEM are from the main STEM teaching requirements. In addition to practical training for teachers on various skills and instructions for STEM planning and teaching such as communication skills, inquiry skills, content knowledge and integration of the four main domains of STEM. They also stated that the number of students per teacher should not exceed 10 students for effective implementation.

In the second domain, the key findings emerge in STEM teaching requirements for students. The most common resulted domain was changing students' role from receiver of knowledge to active learner by training them on various skills such as inquiry skills, engineering designs, using data, literacy skills and collaboration. In addition to enhancing their creativity and innovation skills and increasing their awareness and knowledge of STEM and its main disciplines.

On the other hand, the third domain encloses agreement from groups' respondents on the need to increase stakeholders' awareness of STEM and its practices. Furthermore, there is a need of having the MOEHE to provide suitable flexible semester plan with enough time for STEM implementation, in addition to a well-designed integrated curriculum that includes the four main disciplines of STEM. Moreover, the MOEHE needs to provide some physical necessities such as establishing strong infrastructure for schools, tools and facilities.

Table (10): Teachers’ perceptions of STEM teaching Requirements

Pattern	Key findings	Quotation Examples
Similarity	STEM teaching requirements for teachers	- “Teachers’ awareness, teacher should really know how to Integrate different disciplines to be spontaneous within context.” - “Teachers’ belief in STEM” - “Train teachers on communication skills, teaching inquiry skills, questioning and new ideas for planning the activities.” - “Teacher should know beyond his specialty, he should know more about different disciplines of STEM, so he can link them and guide the students through this system.” - “Practical training for teachers on STEM not theoretical only , there is a gap between How teachers learned and how they are teaching so we have to work more on teaching teachers beliefs and mindset.” - “Changing teachers’ perceptions and attitudes is the right base for enhancing learning, because when the teacher is convinced, he will change the rudder of the entire learning ship.” - “Number of students per teacher should not exceed 10 students for effective follow up of teachers for students.”
Similarity	STEM teaching requirements for Students	- “Enhance students’ creativity and innovation.” - “Changing the students’ role from recipient to developer or generator of new ideas.” - “Students’ awareness and knowledge of STEM with the steps of application of projects.” - “Students’ training on engineering design, then it will be acquired cumulative skills.” - “Training students on open inquiry and its skills, enhance main skills of inquiry.” - “Improve students skills of language, students should know how to read, write, and calculate.” - “Collaboration, the distribution of roles among the group, they must be trained to save time and effort.”

Pattern	Key findings	Quotation Examples
Similarity	STEM teaching requirements related to Stakeholders	- "Stakeholders' awareness in MOEHE of STEM." - "Training of the supervisors and specialists from MOEHE." - "Semester plan alignment between different subjects for same topics at same time." - "Suitable time, suitable tools for each unit or topic, flexible semester plan specified for STEM with enough time for students' interaction." - "Scientific concepts are presented in integrative and cumulative method from different subjects or disciplines and from grade one until grade 6."
Similarity	STEM teaching requirements related to Stakeholders	- "STEM implementation requires suitable integrated curriculum, in addition to strong infrastructure and facilities suitable for implementation." - "Time , facilities , full time laboratory technician" - "A well-designed curriculum that is aligned with STEM specifics."

4.1.3 Teachers' perceptions of the impact of STEM education on students' outcomes.

Sub-question 3: What are science teachers' perceptions of the impact of STEM education on students' outcomes in Qatari public primary schools

4.1.3.1 Quantitative Results (Survey)

The third domain included eight statements related to the impact of STEM education on students' outcomes. Results demonstrated in table (11) show that the overall teachers' perceptions of STEM education impact on students' outcomes is relatively high with an overall mean value (4.10) and standard deviation of (0.62). Remarkably, two statements related to whether "STEM help students acquire critical thinking skills and use of data driven evidence" and "STEM has a positive impact on developing students' creativity" scored the highest mean of value (4.16) and standard deviation of (0.68) and (0.70) respectively. However, the statement stated "STEM prepares students for international standardized assessment such as PISA and TIMSS" scored the lowest mean with value of (3.97) and highest standard deviation of (0.75).

Table (11): Descriptive Statistics of Teachers' perceptions of impact of STEM on students' outcomes.

Statement	Min	Max	Mean	S.D.
STEM helps students acquire skills related directly to STEM careers.	2	5	4.07	0.67
STEM helps students acquire critical thinking skills and use of data driven evidence.	2	5	4.16	0.68
STEM helps students acquire authentic problem solving skills to help in making decisions in the real world.	2	5	4.09	0.70
STEM helps students leverage collaborative learning to execute STEM learning projects.	2	5	4.10	0.71
STEM helps students acquire engineering abilities (define the needs, design, and make a certain product) to make beneficial products.	2	5	4.10	0.73
STEM prepares students for international standardized assessment such as PISA and TIMSS.	2	5	3.97	0.75
STEM has a positive impact on developing students' creativity.	2	5	4.16	0.70
STEM helps students acquire decision-making skills.	2	5	4.11	0.67
Total	2	5	4.10	0.62

4.1.3.2 Qualitative Results (focus groups' interviews)

The present findings from qualitative analysis as shown in table (12) is consistent with the quantitative analysis results that confirm the high teachers' perceptions of the impact of STEM education on students' outcomes. Three main key findings emerged and were related to the impact of STEM education on students' affective dimensions, life and 21st century skills, and their impact on students' achievement in international exams as shown in table (12).

The initial two key findings show similarities between groups' responses. In the first domain, all groups stated that STEM education would have a great impact on students' development to become independent learners. It will increase students' confidence, motivation and enthusiasm for learning. Another promising finding was the impact of STEM on both students' life and 21st century skills. STEM will develop students' life skills for example creative thinking skills, and 21st century skills such as problem solving, critical thinking, and metacognition skills. In contrast to the previous domains, the third domain showed variances in groups' responses; whereas three groups emphasized that STEM will increase achievement of international exams such as PISA and TIMSS. Only one group stated that STEM is not related because international exams depend more on reading and analytical skills, which need further training of students, rather than skills acquired via STEM.

Table (12): Teachers' perceptions of the impact of STEM education on students' outcomes.

Pattern	Key findings	Quotation Examples
Similarity	Impact on students' affective dimensions	- "It will expand students' cognition, It will help them in their lives to think about how and how to make wise decisions according to the data." - "It will build independent learner with specified skills that allow him to face various situations and become creative in real practical life." - "It will increase students' confidence and there is no one correct answer thus this will encourage students to interact more and it will prevent some psychological problems such as embarrassment." - "STEM will increase students' motivation and enthusiasm for learning specially STEM curriculum."

Pattern	Key findings	Quotation Examples
Similarity	Impact on students' life and 21st century Skills	- "Students used to be a thinker rather than receptor of knowledge, where they invent solution for problems facing them in real life." - "Students will acquire critical thinking and creativity skills so students know how to think outside the box, students are aware of their thinking." - "It will improve students' thinking and improve outcomes that are not measured by paper test, it improve their thinking skills." - "It will enhance students' abilities in solving problems and invent solutions that will be reflected on changing his mindset." - "Students will acquire problem solving skills, critical thinking skills and inquiry skills." - "Students can face real life situations and can apply what they learned in real life. Acquired skills will last in real life students will make more connection between subjects area and real life."
Variance	Impact of STEM on students' achievement on International exams	- "It will improve students' achievement in PISA and TIMSS as these international exams based on understanding and application not recalling of information, and STEM will let students think, analyze and solve problems." - "It will improve students achievement in international exams, as students already face same experience in their learning practices , same ideas , based on creative thinking, problem solving , students scientific skills, mathematical skills and this will improve the students learning outcomes."
Similarity	Impact of STEM on students' achievement on International exams	- "Students develop their skills and experiences in STEM in cumulative way, so when we compare students outcomes in TIMSS exam in grade 4 then in grade eight, it will show improvement." - "International exams depends on reading and analyzing skills, as most of the questions is in the form of reading passage and questions, so students should be trained on reading and how to understand the passage, so they can answer the questions."

4.1.4 Teachers' perceptions of the challenges facing STEM implementation.

Sub-question 4: What are the science teachers' perceptions of the challenges facing STEM implementation in Qatari public primary schools?

4.1.4.1 Quantitative Results (Survey)

The last domain of the survey covers eight statements related to the challenges that hinder STEM implementation in Qatari primary public schools. Findings illustrated in table (13) show that the overall teachers' perceptions of the challenges facing STEM implementation is relatively high with an overall mean value (3.99) and standard deviation of (0.60). However, the lack of STEM professional development programs for teachers scored the highest mean value of (4.20) and standards deviation of (0.74). On the other hand, the statement related to the high cost of materials and equipment utilized in STEM lessons got the lowest mean with value of (3.82) and highest standard deviation of (0.88).

Table (13): Descriptive Statistics of Teachers' perceptions of challenges facing STEM implementation.

Statement	Min	Max	Mean	S.D.
Searching and finding an idea to conduct STEM activities.	2	5	3.95	0.72
A need for knowledge enhancement beyond your major, related to STEM subfields.	1	5	3.89	0.79
How to conduct formative assessment for students' achievement in STEM lessons.	1	5	3.85	0.78
Finding extra time for students to conduct STEM lessons.	1	5	4.01	0.82
Materials and equipment utilized in STEM lessons are expensive.	1	5	3.82	0.88
The required experience of teachers in their fields for effective STEM implementation.	1	5	4.10	0.81
Engaging all students in large classrooms.	1	5	4.07	0.87
The insufficient of STEM professional development programs for teachers.	2	5	4.20	0.74
Total	1.875	5	3.99	0.60

4.1.4.2 Qualitative Results (focus groups' interviews)

Based on focus groups interviews, teachers highlighted several challenges that hinder SETM implementation in their classes as stated in table (14). Among these challenges, there is consistency with quantitative results, which specified that insufficient of professional development was the most noticeable one as all the participants declared that there are insufficient STEM training programs for teachers and they stated that QUEMTA is the only professional development program that address STEM in an active learning approach. Other challenges emerged were related to teachers'   as they mentioned that there is a need to change teachers' beliefs and mindset. In addition to the overload of teachers and their limited content knowledge of STEM domains beyond their specialty. Moreover, further challenges raised were the lack of integrated curriculum suitable for implementation, lack of time, large number of students within class, in addition to the need of increasing facilities and tools. Furthermore, there is also the lack of students' basic skills, the inapplicable semester plan and its lack of flexibility. Finally, there are restrictions from stakeholders' side that obstruct the implementation of STEM.

Table (14): Teachers' perceptions of challenges facing STEM implementation.

Challenges	Quotation Examples
Lack of professional development programs	- "There is no enough STEM professional development programs for all teachers." - "There is lack in professional development of STEM, Qatar University Exxon Mobil teachers academy is the only program that present this topic." - "In my school, I am the only one that attend STEM training program."

Challenges	Quotation Examples
Teachers' limitation	- "Teachers are overloaded, curriculum changes and too much paper work." - "Teachers' knowledge of STEM content and how to integrate it within activities." - "Training teachers, changing teachers' beliefs and their acceptance for change." - "There is a gap between how teachers learned, and how they teach and implement. There is need to change beliefs, ideas and mindset of teachers."
Lack of integrated Curriculum	- "The current curriculum is solo disciplines and not integrative, nor cumulative." - "There is no integrated curriculum." - "The current curriculum is not suitable for STEM implementation"
Lack of Time	- "Time and flexibility of semester plan." - "Time needed for implementation" - "Providing enough time for collaborative work for students, enough number of lessons for implementation."
Number of students in the class	- "Number of students in class is too much (more than 15 students per class will struggle the effective implementation)." - "I feel guilty, because I have 30 students and there is no fairness or justice in implementation, I can work with group not with the whole class."
Lack of Facilities	- "Tools and facilities for implementation." - "Budget for training teachers."
Lack of Students' skills	- "Students are not trained from grade 1 and don't have required skills." - "Students are not well trained on required skills." - "Students awareness, their acceptance to this new approach."
Unsuitable Semester plan	- "Number of lessons per week and semester plan is not enough for implementation of STEM." - "Time limitation of semester plan." - "Semester plan should consider training students on basic skills required for effective STEM implementation."
Stakeholder restrictions	- "The regulations per Specialist from ministry of education and higher education and some schools restriction." - "Supervisors are evaluating students' outcome by evaluating content only not skills." - "There is no consistency between MOEHE supervisors" - "Distress from MOEHE, there is no flexibility and enough space for teachers." - "Accountability from MOEHE Supervisors has no unified rules."

Section Two: Variances Analysis

4.2 Are there any statistical significant differences (α= 0.05) in the primary science teachers' perceptions due to gender, educational background, teaching experience, the received professional development programs, STEM teaching experience?

4.2.1 Teachers' perceptions of STEM education according to Gender:

From the following table (15), and with 95% confidence level, there is no any significant difference between males and females in all the indicators. Since the p-values of the T-test are greater than the significance level alpha = 0.05.

Table (15): T-test statistic of teachers' perceptions of STEM education according to Gender

Gender		N	Mean	Std. Error Difference	t	sig.
Teachers' perceptions of STEM education knowledge	Female	130	4.0813	0.1612	-0.1356	0.892
	Male	18	4.1032			
Teachers' perceptions of STEM teaching requirements.	Female	130	4.0958	0.1526	-1.1926	0.235
	Male	18	4.2778			
Teachers' perceptions of the impact of STEM education on students' outcomes.	Female	130	4.0885	0.1563	-0.4558	0.649
	Male	18	4.1597			
Teachers' perceptions of the challenges facing STEM implementation	Female	130	3.9750	0.1501	-0.6291	0.530
	Male	18	4.0694			

4.2.2 Teachers' perceptions of STEM education according to Educational Background

The original educational background variable has four categories (Bachelor – Higher Diploma – Master – Doctoral) recall table (16) of frequencies:

Table (16): Descriptive statistics of teachers according to their teaching experience

Educational Background	Frequency	Percentage
Bachelor	117	79.1
Higher Diploma	11	7.4
Master	19	12.8
Doctoral	1	0.7
Total	148	100

The frequencies in Higher Diploma and doctoral are very few, so the researcher regrouped the data to Bachelor and Post Graduates which includes (Higher Diploma – Master – Doctoral) as shown in table (17):

Table (17): Descriptive statistics according to regrouping of teaching experience

Educational Background	Frequency	Percentage
Bachelor	117	79.1
Post Grad (Higher Diploma – Master – Doctoral)	31	20.9
Total	148	100

Based on the above table (17), the researcher performed the statistical testing using the new groups as shown in table (18). The following table stated that with 95% confidence level, there is no significant difference between teachers with Bachelor degree and teachers with post Graduates degree in all the indicators, since the p-values of the T-test are greater than the significance level alpha = 0.05.

Table (18): T-test statistic of teachers' perceptions of STEM education according to educational background.

Educational Background		N	Mean	Std. Error Difference	T- test	Sig.
Teachers' perceptions of STEM education knowledge	Bachelor	117	4.0794	0.129	-0.170	0.865
	Post Grad	31	4.1014			
Teachers' perceptions of STEM teaching requirements.	Bachelor	117	4.1080	0.123	-0.385	0.701
	Post Grad	31	4.1554			
Teachers' perceptions of the impact of STEM education on students' outcomes.	Bachelor	117	4.0972	0.126	0.004	0.997
	Post Grad	31	4.0968			
Teachers' perceptions of the challenges facing STEM implementation	Bachelor	117	3.9904	0.121	0.154	0.878
	Post Grad	31	3.9718			

4.2.3 Teachers' perceptions of STEM education according to teaching experience

Results from the below table (19) showed that there is no significant difference at 95% confidence level between teachers in relation to different teaching experience in three domains; SETM education knowledge, STEM teaching requirements and impact of STEM education on students' outcome. Since the p-values of the F-test equal (0.129), (0.281) and (0.129) respectively are greater than the significance level alpha = 0.05. Additionally, there is a significant difference between the teachers with different teaching experience years, regarding their perceptions of challenges facing STEM implementation. Since the p-value of the F-test equal (0.013) which is less than the significance level alpha (0.05).

Table (19): ANOVA statistic of teachers' perceptions of STEM education according to teaching experience.

	Teaching Experience	N	Mean	F- test	Sig.
Teachers' perceptions of STEM education knowledge	Less than 5 years	17	4.2353	1.923	0.129
	From 6 to 10 years	43	4.1711		
	From 11 to 15 years	50	4.1114		
	16 years or more	38	3.8816		
	Total	148	4.0840		
Teachers' perceptions towards STEM teaching requirements.	Less than 5 years	17	4.2995	1.288	0.281
	From 6 to 10 years	43	4.1522		
	From 11 to 15 years	50	4.1364		
	16 years or more	38	3.9737		
	Total	148	4.1179		
Teachers' perceptions of the impact of STEM education on students' outcomes.	Less than 5 years	17	4.3456	1.917	0.129
	From 6 to 10 years	43	4.1366		
	From 11 to 15 years	50	4.1050		
	16 years or more	38	3.9309		
	Total	148	4.0971		

	Teaching Experience	N	Mean	F- test	Sig.
Teachers' perceptions about the challenges facing STEM implementation	Less than 5 years	17	4.2574	3.694	0.013
	From 6 to 10 years	43	3.9709		
	From 11 to 15 years	50	4.0825		
	16 years or more	38	3.7566		
	Total	148	3.9865		

Furthermore, the pairwise effect size is summarized in the following table (20):

Table (20): Cohen's D effect size

		Cohen's D
Less than 5 years	From 6 to 10 years	0.481
	From 11 to 15 years	0.294
	16 years or more	0.841
From 6 to 10 years	Less than 5 years	- 0.481
	From 11 to 15 years	-0.187
	16 years or more	0.360
From 11 to 15 years	Less than 5 years	-0.294
	From 6 to 10 years	0.187
	16 years or more	0.547
16 years or more	Less than 5 years	-0.841
	From 6 to 10 years	-0.360
	From 11 to 15 years	-0.547

Cohen's effect size is a quantitative measure of the magnitude of the experimental effect. It shows the relationship between two variables, whereas the greater the effect size indicates stronger relationship and vice versa (Cohen, 1998). According to Cohen (1998), when the value of d equals (0.2), it indicates a 'small' effect size, while (0.5) indicates a 'medium' effect size and (0.8) indicates a 'large' effect size. This means that if two groups' means do not differ by (0.2) standard deviations or more, then the difference is trivial, even if it is statistically significant (Cohen, 1998).

Regardless the sign that indicates the direction of the effect, the magnitude of the Cohen's D showed that:

- There is ignorable effect size between (from 6 to 10 years) and (from 11 to 15 years) since |d| = (0.187) which is less than (0.2) (Cohen, 1998).
- There is small effect size between (Less than 5 years and from 6 to 10 years) of value (0.481), (less than 5 years and from 11 to 15 years) of value (0.294) and from (6 to 10 years and 16 years or more) with value of (0.36). This means that teachers with less than 5 years teaching experience have higher teacher's perception about the challenges facing STEM implementation than teachers with 6 to 10 years teaching experience, teachers with 11 to 15 years teaching experience, teachers more than 16 years of teaching experience.
- There is moderate effect size between from (11 to 15 years) and (16 years or more) since |d| = (0.547) , which indicates that teachers with 11 to 15 years teaching experience have higher teacher's perception about the challenges facing STEM implementation than 16 years teaching experience or more.
- There is strong effect size between (less than 5 years) and (16 years or more) since |d| = (0.841), which indicates that teachers with less than 5 years teaching experience have higher teacher's perception about the challenges facing STEM implementation than 16 years teaching experience or more.

4.2.4 Teachers' perceptions of STEM education according to received STEM professional development programs.

The below table (21) showed that with 95% confidence level, there is significant difference in perceptions between teachers who received STEM related trainings and teachers who did not in three domains: knowledge about STEM education, STEM teaching requirements and the impact of STEM on students' outcomes. Whereas the p-value of the T-test equals (0.000), (0.000) and (0.003) respectively, which is less than the significance level alpha = (0.05). Furthermore, with reference to Cohen D values, there is higher medium size effect for teachers' perceptions who received STEM related trainings than teachers who did not receive it, mainly in the three domains; knowledge about STEM education, STEM teaching requirements, and the impact of STEM on students outcomes, as Cohen's D values scored (0.613), (0.579) and (0.5) respectively (Cohen, 1999) .

However, there is no significant difference on perceptions between teachers who received STEM related trainings and who did not related to the challenges facing STEM implementation. As the p-value of the T-test = (0.372), which is greater than the significance level alpha = (0.05) and with Cohen's D scored (0.15) which is less than (0.2) which indicates ignorable effect size supporting the significance testing results.

Table (21): T-test statistic of teachers' perceptions of STEM education according to received STEM professional development program.

Have you ever received any STEM related training?		N	Mean	Std. Error Difference	T - test	Sig.	Cohen's D
Teachers' perceptions towards knowledge about STEM education	No	88	3.9253	0.102	-3.825	0.000	0.613
	Yes	60	4.3167				
Teachers' perceptions towards STEM teaching requirements.	No	88	3.9752	0.098	-3.599	0.000	0.579
	Yes	60	4.3273				
Teachers' perceptions towards the impact of STEM education on students' outcomes.	No	88	3.9716	0.101	-3.068	0.003	0.500
	Yes	60	4.2813				
Teachers' perceptions about the challenges facing STEM implementation	No	88	3.9503	0.100	-0.895	0.372	0.150
	Yes	60	4.0396				

4.2.5 Variance in teachers' perceptions of STEM education according to STEM teaching experience.

Table (22): T-test statistic of teachers' perceptions of STEM education according to their STEM teaching experience.

Have you taught STEM lesson?		N	Mean	Std. Error Difference	T- test	Sig.	Cohen's d
Teachers' perceptions of STEM education knowledge	No	95	3.9526	0.105611	-3.473	0.001	0.574
	Yes	53	4.3194				
Teachers' perceptions of STEM teaching requirements.	No	95	3.9952	0.100609	-3.406	0.001	0.564
	Yes	53	4.3379				

Have you taught STEM lesson?		N	Mean	Std. Error Difference	T- test	Sig.	Cohen's d
Teachers' perceptions of the impact of STEM education on students' outcomes.	No	95	3.9855	0.103483	-3.012	0.003	0.503
	Yes	53	4.2972				
Teachers' perceptions of the challenges facing STEM implementation	No	95	3.9408	0.101931	-1.252	0.213	0.214
	Yes	53	4.0684				

The previous table (22) with 95% confidence level represented that there is significant difference in perceptions between teachers who teach STEM and teachers who did not in three domains: knowledge about STEM education, STEM teaching requirements and the impact of STEM on students' outcomes. Whereas the p-value of the T-test equals (0.001), (0.001) and (0.003) respectively, which is less than the significance level alpha = (0.05).

Furthermore, with reference to Cohen D values, there is higher medium size effect for teachers' perceptions who teach STEM than teachers who did not in the three domains; knowledge about STEM education, STEM teaching requirements, and the impact of STEM on students outcomes, as Cohen's D values scored (0.574), (0.564) and (0.503) respectively.

Moreover, there is no significant difference in perceptions between teachers who taught STEM lessons and who did not related to the challenges facing STEM implementation as the p-value of the T-test = (0.213) which is greater than the significance level alpha = (0.05). Moreover, Cohen's D = 0.214 which indicates ignorable effect size supporting the significance testing results.

Chapter Five: Discussion and Conclusion

The main purpose of the current study is to examine perceptions of primary science teachers regarding STEM education in Qatari public schools, in addition to investigate challenges that may hinder STEM implementation in primary public schools. Furthermore, the study aims at exploring if there is any significant statistical difference in teachers' perceptions based on gender, educational background, teaching experience, the received STEM professional development programs and STEM teaching experience.

In this chapter, the researcher is discussing and interpreting results presented in chapter four in relation to research questions and discussed literature review. At the end of this chapter, recommendations based on discussion and conclusion presented for further proposals and future studies within the same field.

5.1 What are science teachers' perceptions towards STEM education in public primary schools in Qatar?

Data collected to answer the first question indicate that science teachers in primary public schools in Qatar have relatively high perceptions of STEM education. Overall, there was consistency between quantitative analysis results and qualitative analysis findings to answer the sub questions, which represent the four main domains of the first question in this study. Results obtained agreed with most studies conducted in the MENA region, such as (Al Anzi and Al Gabr, 2017; Al Aitebey, 2018) as they reported high science teachers perceptions' related to STEM education knowledge and STEM teaching requirements. While, Al Basha (2018) specified that STEM education was well perceived by mainstream of teachers in UAE , and Elayyan & Al Shizawi (2019) and Al Salamat, (2019) indicated high perceptions of science teachers towards integrating STEM in teaching science. However, it was in harmony with few studies conducted in other regions such as (Smith et al., 2015, Park et al., 2016; Khuyen et al., 2020), where they all reported that teachers had high perception for STEM education. To discuss these findings thoroughly, the researcher will discuss each sub-question separately.

5.1.1 What are the science teachers' perceptions of STEM education knowledge in Qatari public primary schools?

The first sub-question investigated perceived knowledge about STEM education. Bell (2015) and Nugroho, Permanasari, and Firman (2019) findings stressed on the importance of understanding teachers' knowledge of STEM, as it will reflect on their efficacy and practices upon implementing STEM. Results from the quantitative analysis reported teachers' high perceptions related to their knowledge of STEM education. Knowledge of STEM enclosed description of STEM nature, STEM integrated disciplines, STEM and its relation to future careers, and STEM instructional practices. Teachers showed a high level of knowledge related to linking STEM to real-life problems to enhance students thinking skills. This in turn explain teachers' confidence in emphasizing that problem-based learning is a crucial element in STEM instructional practices. On the other hand, teachers were less confident in their integrating STEM disciplines content. This is considered as common results reported in many studies such as (Al Anzi & Al Gabr, 2017; Al Basha, 2018; Smith et al., 2015). These studies agreed that although high perceptions of teachers towards STEM, yet they still showed less confidence in integrating some disciplines such as technology and engineering, and they need to increase their understanding related to integration of these disciplines within their lessons.

Quantitative data was further confirmed by the qualitative data. Teachers showed variance in describing STEM education in relation to integrated disciplines. Some groups well described STEM as their description includes the main disciplines, its integrative nature and some of its practices such as, "STEM is present in any inquiry or topic by linking science, math, engineering and technology. Technology is any used tools such as measuring tools or computers during research. Problem-solving in STEM includes using numbers, data, calculations, units, data analysis, and engineering design." While others stated that "STEM Link scientific information with different Mathematical branches to deepen theses information via engineering or mathematical calculations". Such response shows that teachers consider engineering one of mathematical branches, which reveals their misconception of their engineering concept and their confusion between "engineering" and "geometry" concepts, which have the same term in Arabic. In addition, teachers did not mention integrating technology as a key element in STEM, which means that teachers need to enhance their understanding of integrated STEM disciplines. This result is in harmony with Al Basha (2018) and Madani (2020) findings that highlighted teachers' lack of ability to provide an accurate definition of STEM and their need to further understand disciplines core concept.

Furthermore, Most of the groups were knowledgeable and of high awareness of STEM aims in relation to future careers. This was clarified from their responses such as: "STEM aims to guide students to STEM related careers, I read a report from the Ministry of Commerce in the USA, and they reported that job opportunities for those with specializations related to mathematics and science increased by 17%''. Moreover, teachers stated, "STEM is a worldwide program, it is a trend adopted by society elite, people who aspire to educate their children at a high level, to enroll their children in STEM Schools because it qualifies them for specialized jobs in the future. On the other hand, one group mentioned that STEM only refer to STEM careers rather than directing and guiding students to these fields. They mentioned, “STEM is not directing students to professions, but rather, it just refers to them, for example, while discussing space, teachers imply that this specialty is important for the future, another example refers to the importance of medical professions."

Conversely, respondents' answers showed obvious knowledge of STEM relation to real life, where all the scientific concepts are applied to solve various real-life problems, and how this enhances students thinking skills to solve these authentic problems. They stated that “STEM is linked to real-life problems due to real-life problems it addresses, for example, extinction of animals, global warming, pollution, all solutions are generated by students, which highlights the importance of finding solutions for real-life problems”. This result aligns with Drake’s (1991) integration theory discussed previously in the literature review. Drake advocated for the transdisciplinary approach in which STEM is connected to real-life applications. Furthermore, focus groups data showed high knowledge and understanding of the main STEM instructional practices: “STEM is based on the 21st-century skills, collaboration and teamwork, finding solutions for real-life problems, critical thinking solving real life problems using the scientific method, integrating and using technology, applying mathematics and different domains of science”. This result aligned with the findings of Wang et al. (2011) and Al Basha (2018) who reported that STEM implementation in classes using problem based learning and project-based learning to solve real-life problems is essential to enhance student’s skills. The results opposes Madani (2020) study results, which pointed out teachers’ imprecision in explaining the main instructional practices of STEM.

5.1.2 What are the science teachers' perceptions of STEM teaching requirements in Qatari public primary schools?

Teachers' perception of the STEM requirement was the highest among the four domains. Results showed that there is a consistency between quantitative and qualitative data, which emphasize the presence of high overall teachers' perceptions of STEM teaching requirements. This result is aligned with the results of Al Anzi and Al Gabr (2017), Al Aitebey (2018) study, which highlighted that teachers had higher perceptions of STEM teaching requirements than their perception of STEM knowledge. Qualitative findings pointed out STEM teaching requirements for teachers are increasing teachers' awareness and beliefs of STEM, changing perceptions and attitudes of teachers towards STEM, in addition to the need of practical training for teachers on various instructions for STEM planning and implementation such as inquiry skills, content knowledge, and approaches for integration STEM domains.

On the other hand, key findings emerged in STEM teaching requirements for students are changing students' role from receivers of knowledge to active learners by training them on various skills such as inquiry skills, engineering designs, using data, literacy skills, and collaboration. In addition, findings included enhancing students' creativity and innovation, and increasing their awareness and knowledge of STEM and its main disciplines. Moreover, the most highlighted findings were related to stakeholders, and the need to increase stakeholders' awareness of STEM and its practices as mentioned as "Increase the stakeholders' awareness of MOEHE on STEM education". Stakeholders are also required to provide suitable flexible semester plan, well-designed integrated curriculum, and some physical requirements such as strong schools infrastructure, tools, and facilities.

5.1.3 What are science teachers' perceptions of the impact of STEM education on students' outcomes in Qatari public primary schools?

Findings in this question showed that the overall teachers' perceptions of STEM education impact on students' outcomes is relatively high, which is aligned with what teachers reported in their interviews. They all confirmed the positive impact of STEM on students' development to as teachers stated, "It will build an independent learner with specified skills that allow him to face various situations and become creative in real practical life". In addition, teachers assured the potential impact of STEM on increasing students' confidence, motivation, and enthusiasm for learning.

Furthermore, a promising finding was the impact of STEM on improving students' life quality and developing 21st-century skills as they mentioned: "STEM will enhance students' abilities in solving problems and design solutions that will be reflected on his mindset'. This result is in harmony with the results of Elayyan and Al-Shizawi (2019) study, which reported that STEM helps to improve students' 21st-century skills, keep pace with modern scientific development.

On the other hand, three of the groups agreed on the impact of STEM on students' achievement in the international exams such as: PISA and TIMSS. Most of the respondents mentioned, "It will improve students' achievement in PISA and TIMSS as these international exams are based on understanding and applying not on recalling information. STEM will allow students to think, analyze and solve problems". Whereas other groups justify the irrelative relation saying, "International exams depend on reading and analyzing skills as most of questions are in essay form. Thus, students should be trained on reading and understanding such questions so they can answer them correctly. Although the different responses in qualitative finding, yet this difference show teachers' awareness and positive perceptions. Whereas they mentioned that literacy skills is a vital element in preparing students and improving their achievement in these international exams. This is highly aligned with the rationalize of changing STEM to STREAM, where the (R) stands for reading and writing and justification for the need to add this disciplines to STEM is the prominence of the literacy skills for effective implementation of integrated curriculum that requires critical thinking and creativity skills.

5.1.4 What are the science teachers' perceptions of the challenges facing STEM implementation in Qatari public primary schools?

With reference to sub-question 4, there is no doubt that identifying the obstacles that might hinder STEM implementation is the first step in its effective implementation in primary classes. Findings revealed several challenges discussed in the section below. Teachers identified challenges that might face STEM implementation based on their practices in science classes, where they use similar instructional practices of STEM such as inquiry, project based learning, and problem-based learning.

Remarkably, there is high consistency between quantitative and qualitative results. Results identified the lack of professional development is the most prominent challenge as all participants stated that there are insufficient STEM training programs for teachers. Additionally, 40% of respondent who attended STEM training programs stated that QUEMTA is the only professional development program that addresses STEM as an active learning approach. This result is similar to the results of Siew, Amir, and Chong (2015); Margot and Kettler (2019) study. Furthermore, this justifies the huge recommendation of implementing more STEM professional development programs for teachers to change their perception of STEM and improve their practices as mentioned in Al Anzi and Al Gabr (2017); Madani and Forawi (2019); Elayyan and

Al- Shizawi (2019); Herro & Quigley (2017)); Altan and Ercan (2016); Nam et al. (2020) studies.

Another challenge emerged is teachers' beliefs and mindset and their limited content knowledge of STEM domains. These challenges are present in various studies that aimed to investigate the impact of STEM professional development programs on teachers' perceptions, beliefs, and practices such as El-Deghaidy &Mansour (2015); Nadelson et al. (2013); Altan and Ercan (2016); Pitiporntapin, et al. (2018); Siew, Amir and Chong (2015) studies.

Moreover, lack of time is a third prominent factor that hinder the implementation from teachers' perspectives. Teachers identified time limitation in various contexts such as time dedicated in semester plans, curriculum, STEM effective implementation, and the time needed for students to work collaboratively. This challenge is in line with those of previous studies conducted by Park et al. (2016); Stubbs and Myers (2016). Furthermore, lack of an integrated curriculum suitable for STEM implementation and a flexible semester plan are challenges facing teachers' implementation of STEM in classrooms. These findings are compatible with findings from Margot and Kettler (2019) study that identified similar challenges including pedagogical, curriculum, and structural challenges. Additionally, the large number of students within the classroom and the need for some facilities and tools are other challenges presented. Finally, constraints imposed by stakeholders is one of the crucial challenges of STEM implementation as they mentioned, "Accountability from MOEHE Supervisors who have no unified rules" and "no consistency between MOEHE supervisors with regards to STEM implementation in classrooms". This result is in consensus with the study of El-Deghaidy &Mansour (2015); Margot and Kettler (2019), which identified challenges related to school management and insufficient support for teachers from stakeholders.

Overall, consistency of quantitative results and qualitative findings in the four sub-questions emphasized the high perceptions of science teachers towards STEM education. Yet, findings highlighted the need to increase teachers' understanding and knowledge of STEM disciplines and their approaches to allow integration. In addition, there is a necessity for further clarification of the main aims of STEM education and its relation to STEM careers, so teachers can consider it in their planning and implementation of various STEM lessons. Accordingly, this will provide a great opportunity for teachers to change their perceptions regarding the impact of STEM on students' achievement especially in international exams such as PISA and TIMSS. Finally, identifying challenges that hinder STEM implementation is considered a primary step to inforce STEM implementation in primary public schools in Qatar. These findings have important implications in providing STEM teaching requirements, improving teachers' awareness, understanding, and practices, and establishing effective professional development programs.

5.2 Do science teachers' perceptions towards STEM education differ due to gender or educational background or teaching experience or the received professional development or STEM teaching experience?

One of the main objective of this study is to identify whether there are differences in teachers' perceptions in terms of gender, educational background, teaching experience, the received professional development programs, and STEM teaching experience. To answer this question, the study examined the statistical question:

"Are there any statistical significant differences (α= 0.05) in the primary science teachers' perceptions due to gender, educational background, teaching experience, the received professional development programs, STEM teaching experience? "

Analyzing data reported that there are no significant statistical differences in relation to gender and educational background. However, there is no difference in perceptions related to teaching experience except for the challenges may hinder STEM implementation. In contrast, there are differences in teachers' perceptions in relation to the received professional development programs and STEM teaching experience in the domains related to STEM Knowledge, STEM teaching requirements and STEM impact on students' outcomes, while there is no differences regarding the challenges that might hinder STEM implementation.

Even though results of the current study shows no significant statistical differences in teachers' perceptions in relation to gender, results of Al Aitebey (2018); Al Basha (2018 reported higher perception in favor to female teachers, while Park et al. (2016)); Smith et al. (2015) scored higher perception in favor of male teachers. Conversely, Madani and Forawi (2019) reported same result of the current study. This contrast of the results with other studies in can be explained in attribution to the fact that MOEHE changed their teaching policy since 2017. They start hiring male teachers for teaching elementary level. This may show that those male teachers exerts some level enthusiasm in teaching primary grade level, which give rise to this result although the female teachers were dominant in number in the current sample. Thus, this result can provide a starting point for MOEHE to construct and stabilize this level of enthusiasm for those teachers.

Similarly, there are no differences in teachers' perceptions according to the educational background of the teachers (bachelor's degree and postgraduate degree). This result is similar to Madani & Forawi (2019), while it shows contrast with Al Salamat (2019) and Khuyen, et al. (2020) studies who reported that there are significant differences in teachers' perceptions attributed to the highest educational background, as they had the more general understanding of STEM education. This result indicates the positive gain of bachelor degree teachers in improving their professional and personal growth.

Data also shows that there is no significant relationship between teachers' perceptions attributed to teaching experience in three domains: STEM education knowledge, teaching requirements, and the impact of STEM on students' outcomes. On the contrary, there is a significant difference between teachers with different teaching experience years' perception regarding challenges facing STEM implementation. Further analysis of data reported that teachers with less than 5 years of teaching experience have higher teachers' perceptions regarding challenges facing STEM implementation than other teachers. This result is consistent with Al Anzi and Al Gabr (2017); Khuyen et al. (2020), whose conclusion stated that there are no significant differences in teachers' perceptions in relation to their teaching experience. Khuyen et al. (2020) justified these results in attribution to other studies who pointed out that the more experience teachers have, the less teachers' enthusiasm for adopting new instructional innovations. However, differences resulted in challenges agree with Al Salamat (2019); Park et al. (2016) study, although they related differences in perceptions in favor of higher teaching experience group. Thus, these highly scored differences in favor of teachers' group who has less than 5 years of experience can be attributed to their limited experience and the need to enhance their practices to decrease challenges they face upon implementing STEM.

Furthermore, results indicated a significant difference in teachers' perceptions in favor of teachers who received STEM professional development in three main domains: STEM education knowledge, STEM teaching requirements, and the impact of STEM education on students' outcomes. In contrast, there is no significant difference between teachers who received STEM training or not regarding the challenges facing STEM implementation. To the researcher's best knowledge, there are no studies investigating the difference in teachers' perceptions in relation to the received STEM professional development program. However, many studies reported the positive impact of professional development programs on teachers' perceptions and practices such as Nadelson et al. (2013); Siew et al. (2015); Altan and Ercan (2016); Herro & Quigley (2017); Nam et al. (2020) studies. This also justify recommendations in several studies to provide STEM specialized professional development programs such as El-Deghaidy & Mansour (2015); AL Anzi & Al Gabr, 2017; Altan and Ercan (2016); Khuyen, et al., 2020 and the recommendation from Al Aitebey (2018) to conduct more studies on the impact of professional development programs on teachers' perceptions and performance.

Findings also indicated that there is a significant difference in perceptions in favor of teachers with STEM teaching experience. The difference is reported in the same three domains; there is a higher medium-size effect for teachers' perceptions who has STEM teaching experience than teachers who do not. There is no difference in teachers' perceptions reported concerning the challenges domain. The consistency between results of teachers' perceptions in relation to receiving STEM professional development and STEM teaching experience in the challenge domain is attributed to similarities between Science and STEM practices and obstacles in authentic classes, and thus most science teachers' can understand and reflect on challenges in STEM implementation.

5.3 Conclusion

The current study has investigated science teachers' perceptions towards STEM education in primary public schools in the State of Qatar. Data were gathered by surveying 148 science teachers and interviewing four focus groups, with a total number of 12 teachers. A web-based survey consisted of two main sections, section one included demographic data, while section two consisted of four main domains: teachers' perceptions towards STEM education knowledge, teachers' perceptions on STEM teaching requirements, teachers' perceptions on the impact of STEM education on students' outcomes and teachers' perceptions on challenges that hinder STEM implementation. Results obtained indicate that science teachers in primary public schools in Qatar have high perceptions towards STEM education in the four main domains. However, findings highlighted the need to increase teachers' understanding and knowledge of STEM disciplines and their approaches of integration. Furthermore, various challenges were reported in this study included lack of professional development, changing teachers' beliefs, increase teachers' knowledge of STEM disciplines and its integrative nature, lack of integrated curriculum, lack of time, large number of students in class, limited students' skills, flexibility of semester plan, and stakeholders' restrictions and awareness.

Finally, data showed that there were no significant differences between teachers' in term of gender, educational background. Moreover, there is no significant difference related to teaching experience in STEM knowledge, STEM teaching requirements and its impact on students outcomes, while there was differences related to challenges hinder its implementation in favor to teachers with less than five years of experience. Furthermore, results indicated significant statistical difference in teachers' perceptions related to the received STEM professional development programs and STEM teaching experience in STEM knowledge, STEM teaching requirements and its impact on students outcomes in favor of teachers who revived STEM training programs and who had STEM teaching experience, while there was no differences related to challenges hinder its implementation.

This study results will benefit the Ministry of Education and Higher Education in Qatar as it provides clear information and statistics on the current teachers' perception of STEM education and challenges that may facing its implementation. The results of the study provide an opportunity to establish an effective STEM professional development programs that aim to enhance teachers' awareness, knowledge, practices, and skills required to implement STEM effectively in public schools. Finally, results of the current study give a new horizon for further research on STEM education field.

5.4 Recommendations

Guided by the results of this study, the researcher recommends that the MOEHE provides science teachers with additional effective STEM professional development programs prepared by specialists in STEM education field. Moreover, developing STEM integrated curriculum and flexible semester plans compatible with the implementation of STEM education by the MOEHE is highly recommended. Finally, more research in STEM education field needs to be conducted for different grade levels such as preparatory and secondary stages.

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Appendix

Appendix 1: Number of primary public schools in Qatar.

الطلاب والمدرسون حسب المرحلة التعليمية والنوع ونوع التعليم

٢٠١٩/٢٠١٨

STUDENTS AND TEACHERS BY LEVEL OF EDUCATION, GENDER AND TYPE OF EDUCATION

2018/2019

TABLE (63) جدول (٦٣)

Education Type / Educational Level & Gender		المجموع Total		المدارس الخاصة(١) Private Schools(1)		المدارس الحكومية Government Schools		نوع التعليم / المرحلة التعليمية والنوع	
		المدرسون Teachers	الطلاب Students	المدرسون Teachers	الطلاب Students	المدرسون Teachers	الطلاب Students		
Pre-primary(2)	Males	456	28,171	456	23,912	0	4,259	ذكور	رياض الأطفال(٢)
	Females	4,187	26,296	3,142	21,615	1,045	4,681	إناث	
Primary	Males	2,677	80,306	1,855	52,997	822	27,309	ذكور	الإبتدائية
	Females	10,416	76,797	4,542	47,429	5,874	29,368	إناث	
Preparatory	Males	2,129	30,587	680	17,094	1,449	13,493	ذكور	الإعدادية
	Females	3,055	29,491	1,394	14,664	1,661	14,827	إناث	
Secondary(3)	Males	2,214	25,489	554	12,081	1,660	13,408	ذكور	الثانوية(٣)
	Females	2,570	24,432	978	10,225	1,592	14,207	إناث	
Total	Males	7,476	164,553	3,545	106,084	3,931	58,469	ذكور	المجموع
	Females	20,228	157,016	10,056	93,933	10,172	63,083	إناث	
	Total	27,704	321,569	13,601	200,017	14,103	121,552	المجموع	

(1) Include Qatar Foundation Schools. (١) تشمل مدارس مؤسسة قطر.

(2) Include nurseries. (٢) تشمل الحضانات.

(3) Include Specialized Secondary. (٣) تشمل الثانوية التخصصية.

Appendix 2: Survey of teachers perceptions towards STEM education

Teacher's Survey

Dear Teacher,

Thank you for taking the time to participate in this survey. This survey investigates science teachers' perceptions towards STEM (Science, Technology, Engineering and Mathematics) education in Qatar. All information will be used for the academic research only and will be held in strict confidentiality. Accordingly, please answer all of the following questions to the best of your knowledge. By completing this survey, you give your consent to participate in this study.

The study is approved by the Qatar University Institutional Review Board with the approval number QU -(QU-IRB 1427-EA/20). If you have any questions related to ethical compliance of the study, you may contact them at QU-IRB@qu.edu.qa. If you have any questions, please contact Mrs. (Hala Fayed Hassan Fathy), hf085754@qu.edu.qa or the supervisor, Dr. Amal Malkawi a.malkawi@qu.edu.qa

Thank you for your participation.

عزيزي المعلم/المعلمة

أشكرك على وقتك الذي ستقضيه في المشاركة في هذا الاستبيان، والذي يهدف إلى تقصي تصورات معلمي العلوم تجاه تعليم STEM (العلوم، التكنولوجيا، الهندسة، والرياضيات) في دولة قطر، علما بأنه سيتم الحفاظ على سرية المعلومات المقدمة، واستخدامها لأغراض البحث العلمي الأكاديمي فقط؛ لذا يرجى منكم الإجابة على جميع الأسئلة، وبإكمال هذا الاستبيان فإنك تعطي موافقتك على المشاركة في هذه الدراسة ...

حصلت هذه الدراسة على الموافقة من قبل وزارة التعليم والتعليم العالي، وكذلك تمت الموافقة من قبل مجلس المراجعة الداخلية في جامعة قطر برقم اعتماد .QU-IRB 1427-EA/20 إذا كان لديك أي سؤال حول الموافقة الأخلاقية للدراسة ، يمكنك التواصل عبر البريد الالكتروني التالي . QU-IRB@qu.edu.qa :اذا كان لديك أي استفسار يمكن التواصل مع الباحثة/هالة فايد حسن فتحي من خلال البريد الإلكتروني :
hf085754@qu.edu.qaأو المشرفة على الرسالة الدكتورة/ أمال ملكاوي من خلال البريد الإلكتروني :
a.malkawi@qu.edu.qa .

أشكر لكم حسن تعاونكم

I. **Demographic Data:** البيانات الديموغرافية

1. Gender **الجنس**	Male ذكر	Female أنثى			
2. Education background: **الخلفية التعليمية**	Bachelor بكالوريوس	Higher Diploma دبلوم عالي	Master ماجستير	Doctoral دكتوراه	Other .... أخرى .....
3. Country of Highest degree **البلد لأعلى شهادة حاصلت عليها**	قطر	أخرى			
4. Teaching Experience **الخبرة التدريسية**	Less than 5 years أقل من 5 سنوات	6 -10 years من 6- 10 سنوات	11- 15 years من 11- 15 سنة	16 years and more 16 سنة وأكثر	
5. Specialty **التخصص**	Biology أحياء	Chemistry كيمياء	Physics فيزياء	Geology جيولوجيا	Other .... أخرى .....
6. School location **موقع المدرسة**	الدوحة	الريان	أم صلال	الخور و الذخيرة	الوكرة
7. Have you ever received any STEM related training? **هل حصلت على أي تدريب مرتبط بتعليم STEM؟**	Yes	No			
8. Have you taught STEM lesson? **هل سبق وقمت بتدريس دروس STEM؟**	Yes نعم	No لا			
9. How is STEM being taught/offered in your school? **كيف يتم تدريس/ تقديم STEM في مدرستك ؟**	Extracurricular activity منهج إثرائي	After school program برنامج ما بعد المدرسة	Regular curriculum منهج منتظم		

ii. Survey الاستبيان

__Directions/ Instructions:__ Please respond to the following questions related to STEM education. In this questionnaire, there is no right or wrong answers. Please give your opinion and choose only one answer. Your thoughtful and candid responses are greatly appreciated.

التعليمات: يرجى الإجابة عن جميع الأسئلة التالية المتعلقة بتعليم STEM. في هذا الاستبيان، لا توجد إجابات صحيحة أو خاطئة. يرجى إبداء رأيك واختيار إجابة واحدة فقط. واستجاباتك المدروسة والصريحة موضع تقدير كبير.

1. **Teachers' perceptions towards knowledge about STEM education.**

1. **تصورات المعلمين نحو المعرفة حول تعليم STEM.**

To what extent do you agree or disagree with the following statements related to STEM education?
إلى أي مدى توافق أو لا توافق على العبارات التالية المتعلقة بتعليم STEM؟

No. رقم	Statement العبارة	Response الاستجابة				
		Strongly agree أوافق بشدة	Agree أوافق	Neutral محايد	Disagree لا أوافق	Strongly disagree لا أوافق بشدة
10	The concept of STEM education is defined as teaching the knowledge, skills, and logical thinking related to STEM careers. يعرف مفهوم STEM بتعليم المعرفة والمهارات والتفكير المنطقي المرتبط بمهن STEM.					
11	STEM education is a connection between subjects within authentic context to enhance students' learning. يدمج تعليم STEM بين المواد في سياق حقيقي لتعزيز تعلم الطلبة.					
12	Teachers can *optionally* combine science, technology, engineering, and mathematics knowledge in the current curriculum to create STEM lessons. يمكن للمعلمين بشكل ***اختياري*** الدمج بين معارف العلوم والتكنولوجيا والهندسة والرياضيات من خلال المنهج الحالي للتخطيط لدروس STEM.					
13	Scientific inquiry and Engineering design are two main themes in a STEM lesson. يعتبر الاستقصاء العلمي والتصميم الهندسي الموضوعين الرئيسيين في دروس STEM.					

14	The term "technology" in STEM is *NOT* solely restricted to the use of technological tools in the classroom, such as computers, projects, and cameras. لا يقتصر مصطلح " التكنولوجيا " في STEM على استخدام الأدوات التكنولوجية في الصف الدراسي، مثل الكومبيوتر والمشاريع والكاميرات.					
15	STEM helps in connecting scientific concepts and knowledge in an interdisciplinary paradigm. يساعد STEM على ربط المفاهيم العلمية والمعارف من خلال نموذج تكاملي متعدد التخصصات.					
16	STEM helps students build scientific explanations and evaluate solutions. يساعد STEM الطلبة على بناء تفسيرات علمية وتقييم الحلول.					
17	STEM enhances students' thinking to generate innovative solutions to real life problems. يعزز STEM تفكير الطلبة لخلق حلول مبتكرة لمشاكل واقعية من الحياة.					
18	Problem based learning is an important element in teaching STEM. يعد التعلم القائم على المشكلات عنصراً مهماً في تدريس STEM.					
19	STEM aims at linking knowledge to global problems such as global warming and saving energy. يهدف STEM إلى ربط المعارف بالقضايا العالمية مثل الاحتباس الحراري وتوفير الطاقة.					
20	STEM allows the diversity of educational context through multiplicity of educational outcomes. يسمح STEM بتنوع السياق التعليمي من خلال تعدد المخرجات التعليمية.					

21	STEM employs a variety of strategies to solve scientific problems with flexibility. يوظف STEM مجموعة متنوعة من الاستراتيجيات لحل المشكلات العلمية بمرونة.					
22	STEM removes barriers between subjects and provides flexibility upon integrating new information. يزيل STEM الحواجز بين المواد، ويوفر المرونة عند دمج المعلومات الجديدة.					
23	STEM allows using different methods and approaches to achieve tasks. يتيح STEM استخدام أساليب وطرق مختلفة لإنجاز المهام.					

2. Teachers' perceptions towards STEM teaching requirements.

2. تصورات المعلمين نحو متطلبات تدريس STEM.

To what extend do you agree or disagree with the following statements about STEM teaching requirements?

إلى أي مدى توافق أو لا توافق على العبارات التالية الخاصة بمتطلبات تدريس STEM؟

No. رقم	statement العبارة	Response الاستجابة				
		Strongly agree أوافق بشدة	Agree أوافق	Neutral محايد	Disagree لا أوافق	Strongly disagree لا أوافق بشدة
24	Teaching STEM requires employing mathematical operations in scientific topics. يتطلب تدريس STEM توظيف العمليات الحسابية في الموضوعات العلمية.					
25	Teaching STEM requires using inquiry based learning. يتطلب تدريس STEM استخدام التعلم المبني على الاستقصاء.					

26	Teaching STEM requires enhancing students' acquisition of communication skills while handling STEM tasks. يتطلب تدريس STEM تعزيز اكتساب الطلبة لمهارات التواصل اثناء القيام بمهام STEM.					
27	Teaching STEM requires training students on engineering design. يتطلب تدريس STEM تدريب الطلبة على التصميم الهندسي.					
28	Teaching STEM requires engaging students in evidence based discussion. يتطلب تدريس STEM إشراك الطلبة في المناقشات المبنية على الأدلة و البراهين.					
29	Teaching STEM requires raising curiosity about natural phenomena and scientific discoveries. يتطلب تدريس STEM إثارة الفضول حول الظواهر الطبيعية و الاكتشافات العلمية.					
30	Teaching STEM requires integrating two or more of STEM fields within one lesson. يتطلب تدريس STEM التكامل بين تخصصين أو أكثر من تخصصات STEM في الحصة الدراسية.					
31	Teaching STEM requires training students to search and investigate using various reliable resources from different disciplines. يتطلب تدريس STEM تدريب الطلبة على البحث و التقصي باستخدام مصادر متنوعة و موثوقة من التخصصات المختلفة.					
32	Teaching STEM requires enhancing students' abilities to solve problems and scientific thinking. يتطلب تدريس STEM تعزيز قدرات الطلبة على حل المشكلات والتفكير العلمي.					

33	Teaching STEM requires using technology to integrate multiple STEM fields. يتطلب تدريس STEM استخدام التكنولوجيا لدمج مجالات STEM المتعددة .					
34	Teaching STEM requires making decisions based on data to understand how to refine ideas further. يتطلب تدريس STEM اتخاذ القرارات بناءً على البيانات لفهم كيفية تحسين الأفكار بشكل أكبر.					

3. Teachers' perceptions towards the impact of STEM education on students' outcomes.

3. تصورات المعلمين نحو أثر STEM على المخرجات التعليمية للطلبة.

To what extent do you agree or disagree with the following statements regarding the impact of STEM education on students' outcomes?

إلى أي مدى توافق أو لا توافق على العبارات التالية عن أثر تعليم STEMعلى المخرجات التعليمية للطلبة؟

No. رقم	Statement العبارة	Response الاستجابة				
		Strongly agree أوافق بشدة	Agree أوافق	Neutral محايد	Disagree لا أوافق	Strongly disagree لا أوافق بشدة
35	STEM helps students acquire skills related directly to STEM careers. يساعد STEM على إكساب الطلبة مهارات تتعلق مباشرة بمهن STEM.					
36	STEM helps students acquire critical thinking skills and use of data driven evidence. يساعد تعليم STEM على إكساب الطلبة مهارات التفكير الناقد واستخدام الأدلة المبنية على البيانات.					
37	STEM helps students acquire authentic problem solving skills to help in making decisions in the real world.					

	يساعد تعليم STEM على إكساب الطلبة مهارات حل مشكلات واقعية أصيلة تساعد على صناعة القرارات في العالم الواقعي.					
38	STEM helps students leverage collaborative learning to execute STEM learning projects. يساعد STEM الطلبة على الاستفادة من التعلم التعاوني؛ لتنفيذ مشاريع STEM التعلمية.					
39	STEM helps students acquire engineering abilities (define the needs, design, and make a certain product) to make beneficial products. يساعد تعليم STEMعلى إكساب الطلبة قدرات هندسية (تحديد الاحتياجات، التصميم وتنفيذ المنتج المحدد) لصنع منتجات مفيدة.					
40	STEM prepares students for international standardized assessment such as PISA and TIMSS. يعد تعليم STEM الطلبة للاختبارات القياسية الدولية مثل اختبار البيزا والتيمز (PISA , TIMSS)					
41	STEM has a positive impact on developing students' creativity. STEM له أثر إيجابي في تطوير مهارات الإبداع لدى الطلبة.					
42	STEM helps students acquire decision-making skills. يساعد STEMعلى إكساب الطلبة مهارات صنع القرار.					

4. Teachers' perceptions about the challenges facing STEM implementation.

4. تصورات المعلمين حول التحديات التي تواجه تطبيق STEM.

To what extent do you agree or disagree on the following items regarding challenges you face or expect to face upon implementing STEM in classes? إلى أي مدى توافق على العبارات التالية عن التحديات واجهتك بالفعل أو تتوقع أن تواجهك أثناء تطبيق STEM؟						
No. رقم	Item بنود	Response الاستجابة				
		Strongly agree أوافق بشدة	Agree أوافق	Neutral محايد	Disagree لا أوافق	Strongly disagree لا أوافق بشدة
43	Searching and finding an idea to conduct STEM activities. البحث وإيجاد فكرة لتطبيق أنشطة STEM.					
44	A need for knowledge enhancement beyond your major, related to STEM subfields. الحاجة إلى تعزيز المعرفة بما يتجاوز تخصصك، والإلمام بالتخصصات الأخرى ل STEM.					
45	How to conduct formative assessment for students' achievement in STEM lessons. كيفية إجراء التقويم البنائي لإنجازات الطلبة أثناء تنفيذ دروس STEM.					
46	Finding extra time for students to conduct STEM lessons توفير وقت إضافي للطلبة لتطبيق دروس STEM.					
47	Materials and equipment utilized in STEM lessons are expensive. غلاء أسعار المواد و المعدات المستخدمة في تطبيق دروس STEM .					
48	The required experience of teachers in their fields for effective STEM implementation. الخبرة اللازمة للمعلمين في تخصصاتهم لتطبيق STEM بفعالية.					
49	Engaging all students in large classrooms. إشراك جميع الطلبة في الفصول ذات الحجم الكبير.					
50	The insufficient of STEM professional development programs for teachers . قلة برامج التطوير المهني القائمة على STEM للمعلمين.					
51	Are there any other challenges? Please specify. هل هناك أي تحديات أخرى؟ يرجى تحديدها					

Appendix 3: MOEHE Approval

وزارة التعليم والتعليم العالي
الصادر جهات خارجيه
1603011320232039
179/2020
18/10/2020

تصريح الموافقة لدخول المدارس

السادة مدراء المدارس الحكومية المحترمين،،،

السلام عليكم ورحمة الله وبركاته،،،

نود إحاطتكم علماً بأن الباحث / الباحثون المرفق لكم بياناتهم، بصدد إجراء دراسة ميدانية في مدرستكم وعليه يرجى التكرم بتسهيل مهمة الباحث ، علماً بأن البيانات ستكون سرية ولأغراض البحث العلمي.

مع الشكر لحسن تعاونكم ،،،

نوف عبدالله مبارك الكعبي

مدير إدارة السياسات والأبحاث التربوية

3

إرشادات عامة

لتيسير عمل الباحث في إعداد الأبحاث التربوية عليه أن يلتزم بجملة من الإرشادات أهمها:

1. الحصول على موافقة وزارة التعليم والتعليم العالي لإجراء البحث / الدراسة، عن طريق مخاطبة إدارة السياسات والأبحاث التربوية قبل تطبيق البحث.
2. أن يشتمل الطلب المقدم من الباحث على :
   أ- خطاب من الجهة التابع لها الباحث مصدقاً.
   ب- نسخة من أدوات البحث تكون مكتملة ومحكمة وفي صورتها النهائية.
   ت- إرفاق استمارة طلب تسهيل مهمة باحث موضحة كافة المعلومات اللازمة.

3. يرتبط موضوع البحث / الدراسة باختصاصات وزارة التعليم والتعليم العالي.
4. تزويد إدارة السياسات والأبحاث التربوية بنسخة من البحث / الدراسة عند الانتهاء ورقياً والكترونياً.
5. التعهد بالمحافظة على سرية المعلومات والبيانات وأن تستخدم لأغراض البحث فقط.
6. تطبيق أدوات البحث / الدراسة قبل مواعيد الاختبارات الفصلية أو النهائية بأكثر من 30 يوماً على الأقل، ويمنع تطبيق لأي أداة في فترات الاختبارات.
7. التقيّد بالتقويم السنوي للمدارس عند تطبيق أدوات البحث / الدراسة.
8. يسمح للباحث مالا يزيد عن 3 أبحاث / دراسات في العام الواحد.
9. قد يتطلب البحث / الدراسة الحصول على رأي الوحدات الإدارية المختصة قبل موافقة إدارة السياسات والأبحاث التربوية، لذا يجب أن يتقدم الباحث بطلبه إلى إدارة السياسات والأبحاث التربوية بوقت كافٍ.
10. لن تقوم الوزارة بتطبيق الأدوات أو إرسال الاستطلاعات إلى المدارس لأي باحث، إلا في حال وجود شراكة بحثية موثقة بين الباحث والوزارة.
11. التقيّد بالفترة الزمنية لتنفيذ البحث، وفي حال التأخر في تطبيق أدوات البحث، يرجى إعادة الطلب.
12. يلتزم الباحث بأخلاقيات البحث المعتمدة، ويحق للوزارة إيقاف العمل على البحث / الدراسة في حال ثبت عكس ذلك.

⌘ أتعهد انا الموقع أدناه بالالتزام بكافة الإرشادات التوجيهية الصادرة من قبل إدارة السياسات والأبحاث التربوية.

اسم الباحث : هالة فايد حسن فتحي

التوقيع :

تسهيل مهمة الباحث في المدارس

بيانات الباحث			
اسم الباحث	هالة فايد حسن فتحي		
الجهة المشرفة (جامعة / كلية)	كلية التربية / جامعة قطر		
جهة العمل	المركز الوطني للتطوير التربوي – كلية التربية – جامعة قطر		
هاتف العمل أو المنزل	انقر أو اضغط هنا لإدخال نص.	الهاتف النقال	66869284
البريد الالكتروني (الوظيفي أو الجامعي)	hf085754@qu.edu.qa		
البريد الالكتروني (الشخصي)	h.fayed33@gmail.com		
الرقم الشخصي	2 8 2 8 1 8 0 3 9 5 8		
التخصص الجامعي	ماجستير المناهج وطرق التدريس و التقويم		

بيانات الاعضاء المشاركين بالبحث			
أسماء المشاركين	1. د. أمال رضا حسن ملكاوي	الهاتف النقال	انقر أو اضغط هنا لإدخال نص.
	2. انقر أو اضغط هنا لإدخال نص.		انقر أو اضغط هنا لإدخال نص.
	3. انقر أو اضغط هنا لإدخال نص.		انقر أو اضغط هنا لإدخال نص.
	4. انقر أو اضغط هنا لإدخال نص.		انقر أو اضغط هنا لإدخال نص.
أسماء أخرى	انقر أو اضغط هنا لإدخال نص.		

بيانات البحث						
عنوان البحث (بالعربي)	دراسة استطلاعية حول تصورات معلمي العلوم نحو تعليم STEM في دولة قطر وتحديات تطبيقها					
عنوان البحث (بالإنجليزية)	Science Teachers' Perceptions towards STEM Education in Qatar and Challenges of its Implementation.					
الغرض من إجراء البحث	☒ إنهاء متطلبات علمية (يذكر) : إنهاء متطلبات درجة الماجستير			☐ غرض آخر (يذكر) : انقر أو اضغط هنا لإدخال نص.		
اسم الفئة المستهدفة	معلمي و معلمات العلوم بالمدارس الحكومية بالمرحلة الابتدائية في دولة قطر					
المرحلة الدراسية للفئة المستهدفة	الابتدائية			العدد	انقر أو اضغط هنا لإدخال نص.	
الجهة المستفيدة من نتائج البحث	كلية التربية – جامعة قطر					
الفترة الزمنية التي ينفذ فيها البحث	تاريخ بدء تطبيق أدوات البحث	2020-10-01	تاريخ نهاية تطبيق أدوات البحث	2021-05-01	الزمن المتوقع لاكتمال البحث	2021-07-01

1

عينة البحث	**معلمي و معلمات العلوم بالمدارس الابتدائية الحكومية في دولة قطر**
ملخص للبحث	يهدف هذا البحث إلى تقصي تصورات معلمي العلوم بالمرحلة الابتدائية في المدارس الحكومية نحو تعليم STEM، ومتطلبات التدريس الخاصة بتطبيقه في الصفوف الدراسية بالإضافة إلى أثره على المخرجات التعليمية للطلبة. سيتم من خلال البحث التقصي عن التحديات لتطبيقه في الصفوف الدراسية للمرحلة الابتدائية بالمدارس الحكومية في دولة قطر. تتبع هذه الدراسة المنهج الوصفي المسحي. يتكون مجتمع الدراسة من جميع معلمي ومعلمات العلوم في المدارس الحكومية للمرحلة الابتدائية، وسيتم حساب حجم العينة بعد تحديد حجم مجتمع العينة وفق أخر الإحصاءات المعلنة من وزارة التعليم والتعليم العالي. سيتم استخدام الاستبيان لجمع البيانات الكمية حول تصورات المعلمين حول تعليم STEM ومتطلبات تدريسه، كما سيتم استخدام مقابلات مجموعات التركيز لجمع البيانات النوعية عن تصوراتهم والكشف عن الفرص والتحديات للتطبيق داخل الصفوف الدراسية.
أهداف البحث	1. تحديد تصورات معلمي العلوم بالمرحل الابتدائية نحو المعرفة بتعليم STEM ومتطلبات تطبيقه داخل الصفوف الدراسية. 2. تحديد تصورات معلمي العلوم بالمرحلة الابتدائية نحو أثر تعليم STEM على المخرجات التعليمية للطلبة. 3. تحديد التحديات التي تعيق تطبيقه داخل الصفوف الدراسية. 4. تقييم الاختلاف في تصورات معلمي العلوم المتعلقة بالمتغيرات الديمغرافية مثل الجنس والخلفية التعليمية والخبرة التدريسية، برامج التطوير المهني المقدمة للمعلمين.
أسئلة البحث	1. ما هي تصورات معلمي العلوم بالمرحلة الابتدائية نحو المعرفة بتعليم STEM في المدارس الحكومية في دولة قطر؟ 2. ما هي تصورات معلمي العلوم بالمرحلة الابتدائية نحو متطلبات تعليم STEM في المدارس الحكومية في دولة قطر؟ 3. ما هي تصورات معلمي العلوم بالمرحلة الابتدائية نحو أثر تعليم STEM على المخرجات التعليمية لطلبة المدارس الحكومية في دولة قطر؟ 4. ما هي تصورات معلمي العلوم بالمرحلة الابتدائية نحو التحديات التي تواجه تطبيق تعليم STEM في المدارس الحكومية في دولة قطر؟ 5. هل هناك علاقة ذات دلالة إحصائية في تصورات معلمي العلوم بالمرحلة الابتدائية نحو تعليم STEM ترجع إلى أي من البيانات الديمغرافية (الجنس، المؤهل العلمي ، الخبرة التدريسية ، برامج التطوير المهني المقدمة لهم)؟
منهج البحث وأدواته **<u>المرفقات المطلوبة:</u>**	⌘ منهج البحث : ستتبع هذه الدراسة التصميم الوصفي المسحي. ⌘ أدوات البحث: 1. استبيان لقياس تصورات المعلمين تجاه تعليم STEM ومتطلباته والعلاقة بين العوامل المختلفة مثل الجنس وخبرة التدريس والخلفية التعليمية بالإضافة إلى برامج التطوير المهني المقدمة للمعلمين وتصورات المعلمين. 2. مقابلات مجموعات التركيز لمناقشة معرفة معلمي العلوم وتصوراتهم عن تعليم STEM والعوامل الرئيسية التي تسهل أو تعرقل تطبيقه داخل الصفوف الدراسية.

1. <u>خطاب من الجهة المشرفة على الباحث.</u>

2. أداة البحث المراد تطبيقها ، بحيث تكون مكتملة و محكمة.

Appendix 4: QU – IRB

جامعة قطر
QATAR UNIVERSITY

Qatar University Institutional Review Board QU-IRB

QU-IRB Registration: IRB-QU-2020-006, QU-IRB, Assurance: IRB-A-QU-2019-0009

November 19th, 2020

Dr. Amal Malkawi
College of Education
Qatar University
Phone: +974 4403 5135
Email: a.malkawi@qu.edu.qa

Dear Dr. Amal Malkawi,

Sub.: Research Ethics Expedited Approval
Ref.: Student, Hala Fayed / e-mail: hf085754@student.qu.edu.qa
Project Title: "Primary Science Teachers' Perceptions towards STEM Education in Qatar and Challenges of its Implementation"

We would like to inform you that your application along with the supporting documents provided for the above project, has been reviewed by the QU-IRB, and having met all the requirements, has been granted research ethics **Expedited Approval** based on the following category(ies) listed in the Policies, Regulations and Guidelines provided by MOPH for Research Involving Human Subjects. Your approval is for one year effective from November 19th, 2020 till November 18th, 2021.

1) Present no more than minimal risk to human subject, and
2) Involve only procedures listed in the following category(ies).
Category 6: Collection of data from voice, video, digital, or image recordings made for research purposes.
Category 7: Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Documents Reviewed: QU-IRB Application Human Subject- Ver 2_Bilingual (1), QU-IRB Application Material Check List, Proposal Hala Fayed Hassan Fathy 19-9-2020, 1- Focus group questions – Arabic, 2- Teacher's Survey – Arabic, Teachers' Consent Form - Focus group interview, Teachers' Consent form – Questionnaire, تسهيل مهمة الباحث في المدارس للباحثين- هالة فايد حسن فتحي, QU-IRB Review Forms, responses to IRB queries and updated documents.

Please note that expedited approvals are valid for a period of **one year** and renewal should be sought one month prior to the expiry date to ensure timely processing and continuity. Moreover, any changes/modifications to the original submitted protocol should be reported to the committee to seek approval prior to continuation.

Your Research Ethics Expedited Approval Number is: **QU-IRB 1427-EA/20**. Kindly state this number in all your future correspondence to us pertaining to this project. In addition, please submit a closure report to the QU-IRB upon completion of the project.

Best wishes,
Dr. Ahmed Awaisu
Chairperson, QU-IRB

جامعة قطر
QATAR UNIVERSITY
Institutional Review Board
(IRB)
Office Of Academic Research

Qatar University-Institutional Review Board (QU-IRB), P.O. Box 2713 Doha, Qatar
Tel +974 4403-5307 (GMT +3hrs) email: QU-IRB@qu.edu.qa

Appendix 5: Focus group Interview Protocol

ملحق 1

أسئلة مجموعة التركيز

ستناقش أسئلة مجموعات التركيز القضايا التالية:

1) المعرفة بتعليم STEM.
2) متطلبات تدريس STEM
3) تأثير STEM على المخرجات التعليمية للطلبة
4) التحديات التي تواجه تطبيق STEM.

ملحق 2

بروتوكول المقابلة

قل للمشاركين: شكرًا لكم مرة أخرى على المشاركة اليوم. أنتم أحرار في الانسحاب في أي وقت أثناء المقابلة دون إبداء أي سبب ودون أن تكون هناك عواقب سلبية. سأطرح عليكم أسئلة حول دروس العلوم وكيف يمكنك استخدامها لتقديم مشاكل الحياة الواقعية من المجتمع للطلبة. وهذا يتطلب من الطلبة للتعامل مع مثل هذه المشكلات استخدام المعارف والمهارات من التخصصات المختلفة، حيث لا تكون المشكلات مقصورة على أحد التخصصات دون الأخر. أنا مهتمة بالدروس التي تدعم تطوير مهارات القرن الواحد والعشرون مثل التفكير الناقد والبحث والتواصل ومهارات العرض والتي تساعد في تأهيل الطلبة للمهن المستقبلية. يمكن أن تشمل هذه الدروس أنشطة داخل أو خارج الفصل الدراسي لتعزيز تعليم العلوم كمسار لمزيد من التعلم والتدريب والتطبيق. سيكون من المثير للاهتمام معرفة آرائك حول كيفية تقديم الأفكار الأساسية في مادة العلوم بدلاً من التأكيد على المعرفة والحقائق فقط. أخيرًا، كيف ترى التحديات التي تواجه تطبيق STEM التكاملي داخل صفوف العلوم. لا توجد إجابات صحيحة أو خاطئة على الأسئلة هنا.

ابدأ تشغيل مسجل الصوت.

قل للمشاركين: أنا هالة فايد حسن (أسم المحاور)، سأقوم بإجراء المقابلة (رقم المجموعة) _____ في _____ (التاريخ). نحن نسجل هذه المقابلة بالصوت/ فيديو . هل هذا مناسب لكم؟ (انتظر الرد الإيجابي)

تصورات تطبيق STEM في فصول العلوم ومتطلبات تدريسها.

قل للمشاركين: نريد معرفة المزيد عن كيفية تدريس STEM في صفوف العلوم.

1. ما هي خبرتك في التدريس؟
2. هل يمكنك دمج التخصصات الأخرى مع العلوم في درس؟

3. هل يمكن ربط دروس العلوم بقضايا ومشكلات الحياة الواقعية التي تركز على الوظائف أو المهن المستقبلية؟

4. هل أنت على دراية بمفهوم STEM؟

5. ماذا يتبادر إلى ذهنك عندما تسمع STEM؟

6. ما هي متطلبات تدريس STEM؟

تصورات عن أثر STEM على المخرجات التعليمية للطلبة والتحديات الرئيسية التي تواجه تطبيقه في الصفوف

قل للمشاركين: الأسئلة التالية مصممة لكي نعرف أفكارك فيما يتعلق بتأثير STEM على المخرجات التعليمية للطلبة والتحديات التي تواجه تطبيقه في الصفوف الدراسية.

1. هل تعتقد أن نهج STEM سيحسن معايير التعليم في قطر؟ كيف؟

2. ما هي أهمية نهج STEM على مخرجات التعلم؟

3. ما مدى شعورك بالراحة حيال دمج STEM في دروسك؟

4. هل تلقيت أي تدريب متعلق ب (STEM)؟ ما هو التدريب الإضافي الذي تحتاجه لتكون ناجحًا أو أكثر نجاحاً في تطبيق دروس STEM؟

5. هل تعتقد أن المعلمين مهيئين ومجهزين بشكل جيد لتدريس STEM؟

6. ما هي الفرص التي تسهل تطبيق STEM في صفوف العلوم؟

7. في رأيك، ما هي أهم ثلاثة تحديات تواجه تطبيق STEM؟ يرجى ترتيب أهم 3 تحديات لديك بحيث يكون 1 هو الأكبر.

Appendix 6: Consent form for Survey

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الموافقة على المشاركة في الدراسة

استبيان المعلمين

عنوان الدراسة:

تصورات معلمي العلوم نحو تعليم STEM في المدارس الحكومية الابتدائية في دولة قطر وتحديات تطبيقها

أهداف الدراسة:

تهدف هذه الدراسة إلى تقصي تصورات معلمي العلوم بالمرحلة الابتدائية تجاه تعليم STEM من حيث المعرفة به، ومتطلبات تدريسه، وتأثيره على المخرجات التعليمية للطلبة، والتحديات التي تعيق تطبيقه في الفصول الدراسية في المدارس الحكومية الابتدائية في دولة قطر.

المنافع والمخاطر:

المنافع: لو وافقت على المشاركة في هذه الدراسة، فالمتوقع هو أن تستفيد من خلال التأمل في تصوراتك عن تعليم STEM من عدة محاور أساسية منها المعرفة بأسس تعليم STEM، ومتطلبات تدريسه، وأثره على المخرجات التعليمية للطلبة، بالإضافة إلى التأمل في التحديات الفعلية التي تواجه تطبيقه في الصفوف الدراسية من خلال المشاركة في هذه الدراسة.

المخاطر: إنّ المخاطر التي يمكن أن تنجر عن المشاركة في هذه الدراسة ضئيلة جدا. فليس هنالك مخاطر متوقعا أن تطالك أثناء المشاركة في هذه الدراسة.

الإجراءات:

سوف تشارك في هذه الدراسة عن طريق الإجابة على استبيان يمكن أن يستغرق ما بين 15 إلى 20 دقيقة. لا يتم التعامل مع الإجابات على الاستبيان على أساس الصح والخطأ فلا توجد إجابات صحيحة أو خاطئة في هذا الاستبيان. أي معلومات أو تفاصيل شخصية يتم جمعها أثناء الدراسة هي سرية. ولن يتم تحديد هوية أي شخص أثناء نشر النتائج. المشاركة في هذه الدراسة لن يكون لها أي تأثير على وضعك الوظيفي.

المحافظة على السرية:

ستحفظ جميع الاستجابات للاستبيان بسرية تامة وسيطلع عليها الباحثون وفريق العمل فقط. إذا تم نشر نتائج هذا البحث، سيتم عرض البيانات بشكل جماعي ولن يتم الكشف عن هوية المشاركين.

المشاركة الطوعية:

تعتبر المشاركة في هذه الدراسة طوعية تمامًا، ولست مجبراً على المشاركة. وإذا قررت المشاركة، فأنت حر في الانسحاب في أي وقت أو عدم الإجابة عن أي سؤال من أسئلة الاستبيان دون أن تضطر إلى إعطاء سبب ودون عواقب. بإمكانك انهاء مشاركتك في الدراسة في أي مرحلة من مراحل البحث.

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لديك الحق بالاطلاع على نتائج هذه الدراسة عند الانتهاء منها. بعد نشر أوراق بحثية من هذه الدراسة ستكون الأوراق متاحة للجميع.
كما ننوه إلى أنه تمت الموافقة على الجوانب الأخلاقية لهذه الدراسة من قبل وزارة التعليم والتعليم العالي في دولة قطر ومجلس المراجعة الداخلية في جامعة قطر.

يقوم بعمل هذا البحث الباحثة /هالة فايد حسن فتحي من أجل الاستيفاء جزئي لمتطلبات أطروحة الماجستير في جامعة قطر. اذا كان لديك أي استفسار يمكن التواصل على الهاتف : 66869284 974+ أو البريد الإلكتروني :

hf085754@qu.edu.qa

أو المشرفة على الرسالة الدكتورة/ أمال ملكاوي على الهاتف 9744403-5135 + ، البريد الإلكتروني :

a.malkawi@qu.edu.qa (جامعة قطر ، كلية التربية ، مكتب رقم 113) .

رقم الموافقة على QU-IRB هو ....، إذا كان لديك أي سؤال حول الموافقة الأخلاقية للدراسة ، يمكنك التواصل عبر البريد الالكتروني التالي: QU-IRB@qu.edu.qa .

الرجاء الاطلاع على المعلومات أعلاه بدقة قبل التوقيع. فمن خلال النقر على خانة التالي، تصرحون بفهمكم لغرض الدراسة والموافقة على المشاركة في الاستبيان.

أوافق على المشاركة في الدراسة البحثية. أنا أفهم الغرض من هذه الدراسة وطبيعتها وأنا أشارك فيها طواعية. أفهم أنه يمكنني الانسحاب من الدراسة في أي وقت دون أي عواقب.

- نعم
- لا

Appendix 7: Consent form – Focus Group Interview

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الموافقة على المشاركة في الدراسة

استبيان المعلمين

عنوان الدراسة:

تصورات معلمي العلوم نحو تعليم STEM في المدارس الحكومية الابتدائية في دولة قطر وتحديات تطبيقها

أهداف الدراسة:

تهدف هذه الدراسة إلى تقصي تصورات معلمي العلوم بالمرحلة الابتدائية تجاه تعليم STEM من حيث المعرفة به، ومتطلبات تدريسه، وتأثيره على المخرجات التعليمية للطلبة، والتحديات التي تعيق تطبيقه في الفصول الدراسية في المدارس الحكومية الابتدائية في دولة قطر.

المنافع والمخاطر:
المنافع: لو وافقت على المشاركة في هذه الدراسة، فالمتوقع هو أن تستفيد من خلال التأمل في تصوراتك عن تعليم STEM من عدة محاور أساسية منها المعرفة بأسس تعليم STEM، ومتطلبات تدريسه، وأثره على المخرجات التعليمية للطلبة، بالإضافة إلى التأمل في التحديات الفعلية التي تواجه تطبيقه في الصفوف الدراسية من خلال المشاركة في هذه الدراسة.

المخاطر: إنّ المخاطر التي يمكن أن تنجر عن المشاركة في هذه الدراسة ضئيلة جدا. فليس هنالك مخاطر متوقعا أن تطالك أثناء المشاركة في هذه الدراسة.

الإجراءات:
سوف تشارك في هذه الدراسة عن طريق الإجابة على استبيان يمكن أن يستغرق ما بين 15 إلى 20 دقيقة. لا يتم التعامل مع الإجابات على الاستبيان على أساس الصح والخطأ فلا توجد إجابات صحيحة أو خاطئة في هذا الاستبيان. أي معلومات أو تفاصيل شخصية يتم جمعها أثناء الدراسة هي سرية. ولن يتم تحديد هوية أي شخص أثناء نشر النتائج. المشاركة في هذه الدراسة لن يكون لها أي تأثير على وضعك الوظيفي.

المحافظة على السرية:
ستحفظ جميع الاستجابات للاستبيان بسرية تامة وسيطلع عليها الباحثون وفريق العمل فقط. إذا تم نشر نتائج هذا البحث، سيتم عرض البيانات بشكل جماعي ولن يتم الكشف عن هوية المشاركين.

المشاركة الطوعية:
تعتبر المشاركة في هذه الدراسة طوعية تمامًا، ولست مجبراً على المشاركة. وإذا قررت المشاركة، فأنت حر في الانسحاب في أي وقت أو عدم الإجابة عن أي سؤال من أسئلة الاستبيان دون أن تضطر إلى إعطاء سبب ودون عواقب. بإمكانك انهاء مشاركتك في الدراسة في أي مرحلة من مراحل البحث.

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المشاركة الطوعية:
تعتبر المشاركة في هذه الدراسة طوعية تمامًا، ولست مجبراً على المشاركة. وإذا قررت المشاركة، فأنت حر في الانسحاب في أي وقت أو عدم الإجابة عن أي سؤال من أسئلة الاستبيان دون أن تضطر إلى إعطاء سبب ودون عواقب. بإمكانك انهاء مشاركتك في الدراسة في أي مرحلة من مراحل البحث.

لديك الحق بالاطلاع على نتائج هذه الدراسة عند الانتهاء منها. بعد نشر أوراق بحثية من هذه الدراسة ستكون الأوراق متاحة للجميع.
كما ننوه إلى أنه تمت الموافقة على الجوانب الأخلاقية لهذه الدراسة من قبل وزارة التعليم والتعليم العالي في دولة قطر ومجلس المراجعة الداخلية في جامعة قطر.

يقوم بعمل هذا البحث الباحثة /هالة فايد حسن فتحي من أجل الاستيفاء الجزئي لمتطلبات أطروحة الماجستير في جامعة قطر. اذا كان لديك أي استفسار يمكن التواصل على الهاتف : 66869284 974+ أو البريد الإلكتروني : hf085754@qu.edu.qa أو المشرفة على الرسالة الدكتورة/ أمال ملكاوي على الهاتف 9744403-5135 + ، البريد الإلكتروني : a.malkawi@qu.edu.qa (جامعة قطر ، كلية التربية ، مكتب رقم 113) .

رقم الموافقة على QU-IRB هو ....، إذا كان لديك أي سؤال حول الموافقة الأخلاقية للدراسة ، يمكنك التواصل عبر البريد الالكتروني التالي: QU-IRB@qu.edu.qa .

الرجاء الاطلاع على المعلومات أعلاه بدقة قبل التوقيع. فمن خلال النقر على خانة التالي، تصرحون بفهمكم لغرض الدراسة والموافقة على المشاركة في الاستبيان.

أوافق على المشاركة في الدراسة البحثية. أنا أفهم الغرض من هذه الدراسة وطبيعتها وأنا أشارك فيها طواعية. أفهم أنه يمكنني الانسحاب من الدراسة في أي وقت دون أي عواقب.

- نعم
- لا

أوافق على تسجيل صوت المقابلة.

- نعم
- لا

توقيع المشارك: ______________________ **التاريخ** ______________________
توقيع الباحثة المشاركة: ______________________ **التاريخ** ______________________