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TEACHERS' PERCEPTIONS TOWARDS STEM EDUCATION AND CHALLENGES OF ITS IMPLEMENTATION IN SELECTED PRIMARY SCHOOL IN MEZAM DIVISION

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ATTENTION

DEDICATION

This Thesis is dedicated to my beloved parents TCHOUOLA Théophile and DOUNALA Virginie for their endless support,

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The realization of this piece of work could not have been successful, without the assistance, encouragement, material and financial support from some kind-hearted people.

First of all, I wish to express by sincere thanks and gratitude to my supervisor Professor NDI Julius NSAMI, for making this dissertation possible. His fatherly support, guidance, advice throughout this project, as well as his pains-staking effort in proof reading the work and correcting, is greatly appreciated. Indeed, without his guidance, comments, remarks and engagement, I would not have been able to realize this academic piece.

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LIST OF ABBREVIATIONS

ANOVA:	Analysis of Variance
CAPIEMP:	Teachers' Grade One Certificate
MINEDUB:	Minister of Basic Education
PISA:	Program for International Student Assessment
STEM:	Science, Technology, Engineering and Mathematics
TIMSS:	Trends in International Mathematics and Science Study
UY1:	University of Yaounde 1

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ABSTRACT

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 and challenges of its implementation in selected primary schools in Mezam Division, in 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 are 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.

RESUME

Comprendre les perceptions des enseignants sur l'éducation STEM est crucial pour garantir la qualité de l'enseignement et de l'apprentissage dispensés aux élèves en classe. Cette étude visait à étudier les perceptions des enseignants de sciences à l'égard de l'enseignement STEM et les défis de sa mise en œuvre dans certaines écoles primaires de la division de Mezam, dans quatre domaines : les connaissances des enseignants, les exigences de l'enseignement STEM, l'impact sur les résultats des élèves et les défis perçus de la mise en œuvre. Cette étude a suivi une approche séquentielle explicative à méthodes mixtes. Des données quantitatives ont été recueillies en interrogeant (148) professeurs de sciences, tandis que des données qualitatives ont été obtenues à l'aide de quatre groupes de discussion. Les résultats ont mis en évidence la nécessité d'accroître la compréhension et les connaissances des enseignants sur les disciplines STEM et leurs approches d'intégration. En outre, divers défis ont été signalés, notamment un développement professionnel insuffisant, l'évolution des convictions des enseignants, l'absence d'un programme intégré et le manque de temps. De plus, les résultats ont indiqué qu'il n'y avait pas de différences significatives dans les perceptions des enseignants en ce qui concerne le sexe ou le parcours éducatif, alors qu'il existe des différences en ce qui concerne l'expérience d'enseignement dans le domaine des défis. De plus, les résultats ont indiqué une différence significative dans les perceptions des enseignants concernant les programmes de développement professionnel STEM reçus et l'expérience d'enseignement STEM dans les trois premiers domaines. Sur la base des résultats, l'étude a recommandé qu'il soit nécessaire de développer un programme d'études intégré STEM et de proposer des programmes de développement professionnel STEM.

CHAPTER ONE: INTRODUCTION

Education serves as the bedrock of societal advancement, and in the 21st century, Science, Technology, Engineering, and Mathematics (STEM) education stands out as pivotal in equipping students for the swiftly evolving landscape (Bybee, 2013; Capraro & Slough, 2014). The Mezam Division, located in the North West Region of Cameroon, reflects global apprehensions regarding the effective execution of STEM education at the primary level. As educational systems worldwide embrace STEM's transformative potential, it becomes imperative to grasp the perspectives of primary school educators and the hurdles they confront in embedding STEM principles into their classrooms.

STEM education's importance lies in its ability to nurture critical thinking, problem-solving aptitude, and innovation among students. It transcends conventional disciplinary confines, fostering an interdisciplinary approach mirroring real-world problem-solving intricacies. In the Mezam Division, akin to numerous other regions, policymakers acknowledge the necessity of arming students with skills essential for navigating a technologically advanced, globally interconnected society. Despite recognizing the significance of STEM education, scant research has delved into the specific challenges primary school educators encounter in the Mezam Division.

Globally, STEM education is recognized as a catalyst for technological progress and economic prosperity. Nations worldwide are heavily investing in STEM education to ensure their workforce is equipped with skills requisite for future employment. According to the World Economic Forum, occupations related to STEM are poised for substantial growth, with proficiency in STEM fields increasingly becoming a prerequisite for success across diverse career paths (World Economic Forum, 2018).

Educators wield considerable influence in the effective implementation of any educational endeavor, and STEM education is no exception. Comprehending educators' perceptions toward STEM education proves crucial for crafting effective curricula and tailored professional development initiatives. Prior research underscores the significance of educators' beliefs and attitudes in shaping the success of STEM education endeavors (Bleicher, 2014; Windschitl, 2018). In the Mezam Division, there remains a dearth of understanding regarding primary school educators' perspectives on STEM education and the factors influencing their attitudes.

The implementation of STEM education at the primary level is not devoid of challenges. Scarce resources, inadequate training, and potential cultural barriers stand out as common impediments confronting educators in integrating STEM principles into their pedagogy (Bybee, 2013; Capraro & Slough, 2014). In the Mezam Division context, where educational infrastructure and socio-cultural dynamics may vary, a nuanced comprehension of these challenges assumes paramount importance."

Research Problem

The analysis of elementary school students' performance in the First School Leaving Certificate Exams (2019-2023) highlighted a significant inadequacy in their proficiency in Mathematics and Science (First School Leaving Certificate Exams Results, 2023). Moreover, the Mezam Division played a substantial role in the Trends in Mathematics and Science Achievement study over the span of four years (2020-2023). This initiative aimed to offer a comprehensive insight into students' scientific and mathematical knowledge and skills. According to the findings of the 2023 First School Leaving Certificate Exams, there has been a noticeable improvement in mean performance across assessment periods for both subjects. However, the results underscored that the performance of Mezam Division students remains below compared to the overall average Bryan et al., 2015; Roehrig et al., 2012; Stohlmann et al., 2011). In comparison to other urban regions, it is crucial to scrutinize various factors and dimensions. The education report summary for the academic years 2019-2023 strongly advocates for enhancing student achievement in Mathematics, Science, and English. Additionally, the research underscores the importance of aligning students' academic accomplishments with teaching methodologies. This underscores the necessity of evolving instructional strategies to nurture students' abilities and foster their higher-order cognitive skills. Pursuing this objective, MINEDUB has embraced the initiative of STEM education, heralding a significant transformation in educational paradigms. STEM education facilitates a shift towards creative and interdisciplinary domains, engaging students in the exploration of natural phenomena. Moreover, it redefines the traditional teacher's role into that of a learning facilitator, guiding students through their exploration, inquiry, and problem-solving endeavors. This approach also aims to bolster students' motivation for critical thinking, fostering the cultivation of diverse and innovative solutions to real-world challenges. According to Ahmed (2016), the Ministry of Education in Cameroon, referred to as MINEDUB, introduced the integration of Science and Technology into the newly revised Primary Curriculum in 2018. The primary objective of the Cameroon New Primary Curriculum is to enrich the attainment of learning objectives encompassing 21st century skills, with the ultimate aim of increasing the proportion of secondary school students pursuing studies in specialized STEM subjects.

Moreover, prior research suggests that teachers' execution of STEM education is notably influenced by their perceptions, which are shaped by their understanding of the interconnections among STEM disciplines and the rigorous instructional demands (El-Deghaidy & Mansour, 2015; Ambo Saedey, Al-Harthy & Al Shehemy, 2015; Wang, Moore, Roehrig & Park, 2011). Consequently, assessing educators' viewpoints on STEM education will yield valuable insights for devising innovative pedagogical strategies and sustaining STEM initiatives (Khuyen et al., 2020). Similarly, numerous studies have explored the perceptions of science teachers across various global contexts. However, it's noteworthy that most of these studies have been conducted in different settings. To the best of the researcher's knowledge, there remains an urgent need for further investigation into this subject, employing diverse methodologies, particularly within the North West region as a whole and specifically within the Mezam Division.

Therefore, the present study aims to fill a research gap in the realm of STEM education, particularly in Cameroon. Its objective is to examine the perceptions of primary science teachers regarding STEM education and identify barriers that may hinder its implementation in primary public schools within Mezam Division. Additionally, this study seeks to determine if there are any disparities in teachers' perspectives concerning various factors, including gender, educational background, teaching experience, participation in professional development programs, and expertise in STEM teaching.

Research Objectives:

1. To assess science teachers' knowledge of STEM education.
2. To determine the teaching requirements for effective STEM education.
3. To evaluate the impact of STEM education on students' outcomes.
4. To identify challenges that may hinder the implementation of STEM education.

Research Questions:

1. What is the current level of science teachers' knowledge regarding STEM education concepts and principles?
2. What are the key teaching methods and strategies necessary for the effective implementation of STEM education in the classroom?

3. How does the implementation of STEM education impact students' academic performance, problem-solving skills, and overall engagement in science and math subjects?
4. What are the primary challenges that science teachers face when attempting to incorporate STEM education into their curriculum?

Hypotheses:

1. H0: Science teachers have a similar level of knowledge regarding STEM education concepts and principles.
   H1: Science teachers' knowledge of STEM education varies significantly.
2. H0: The teaching methods for effective STEM education are consistent across different educational settings.
   H1: There are significant variations in teaching methods for effective STEM education based on educational settings.

3. H0: There is no significant difference in students' academic performance, problem-solving skills, and overall engagement in science and math subjects between those exposed to STEM education and those following traditional methods.
   H1: The implementation of STEM education significantly improves students' academic performance, problem-solving skills, and overall engagement in science and math subjects.

4. H0: There are no significant challenges hindering the implementation of STEM education in schools.
   H1: Various challenges significantly hinder the implementation of STEM education in schools.

Research Significance:

1. Improving Science Education: Enhancing the quality of science education by identifying areas for improvement in teachers' knowledge of STEM education.
2. Enhancing Teaching Practices: Providing insights into the skills and pedagogical approaches needed for effective STEM instruction.
3. Student Academic Achievement: Evaluating the impact of STEM education on academic performance and critical thinking skills.
4. Addressing Implementation Challenges: Identifying obstacles to the widespread adoption of STEM education and developing strategies to overcome them.

5. Informing Educational Policy: Providing data-driven insights to inform decisions regarding investments in teacher training and curriculum development.
6. Contributing to Research Literature: Adding to the body of research on STEM education for future studies to build upon.
7. Preparation for a STEM Workforce: Ensuring students are prepared for careers in STEM-related fields.
8. Economic Competitiveness: Assessing the role of STEM education in economic competitiveness on a global scale.

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.

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.

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 to increase the number of students involved in STEM education, deepen students understanding of each discipline, encourage students to choose STEM careers in their future professions, and raise workforce skills to become STEM literate (Kanadli, 2019).

Many studies advocate the promising STEM education approach and its significant effectiveness in 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 have attempted to provide a definition that has been developed over 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) 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).

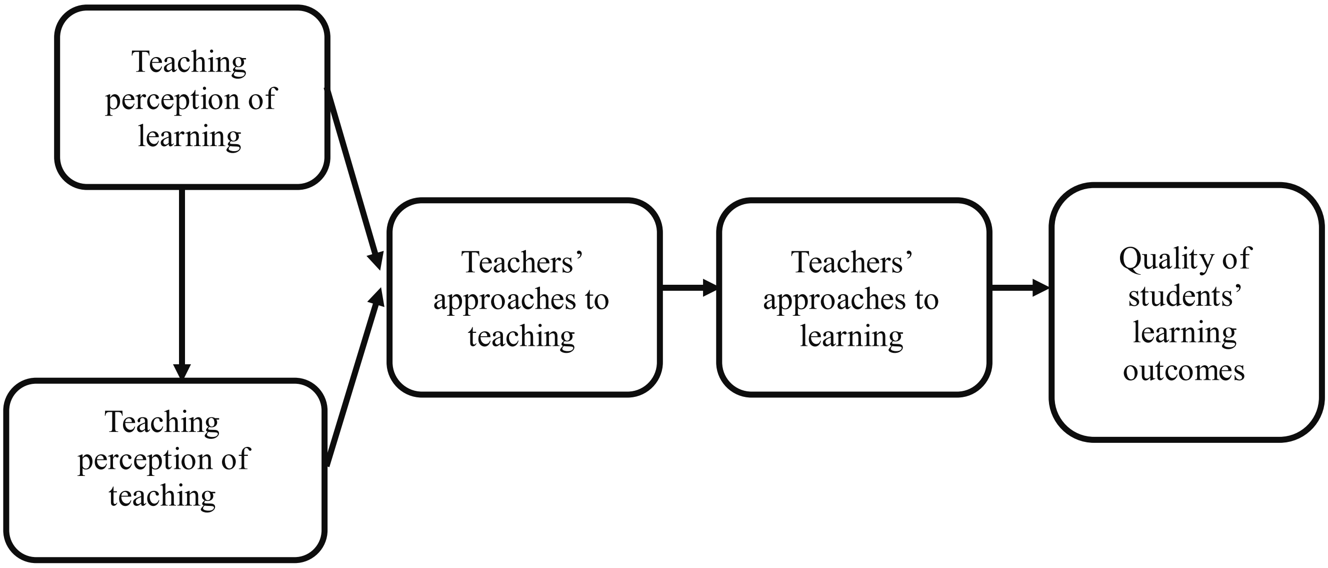

Figure 1: The relation between teachers' perceptions and students' learning outcomes

In the focus of STEM education, The National Research Council (NRC) (2007) stressed on the importance of teaching STEM at Primary 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).

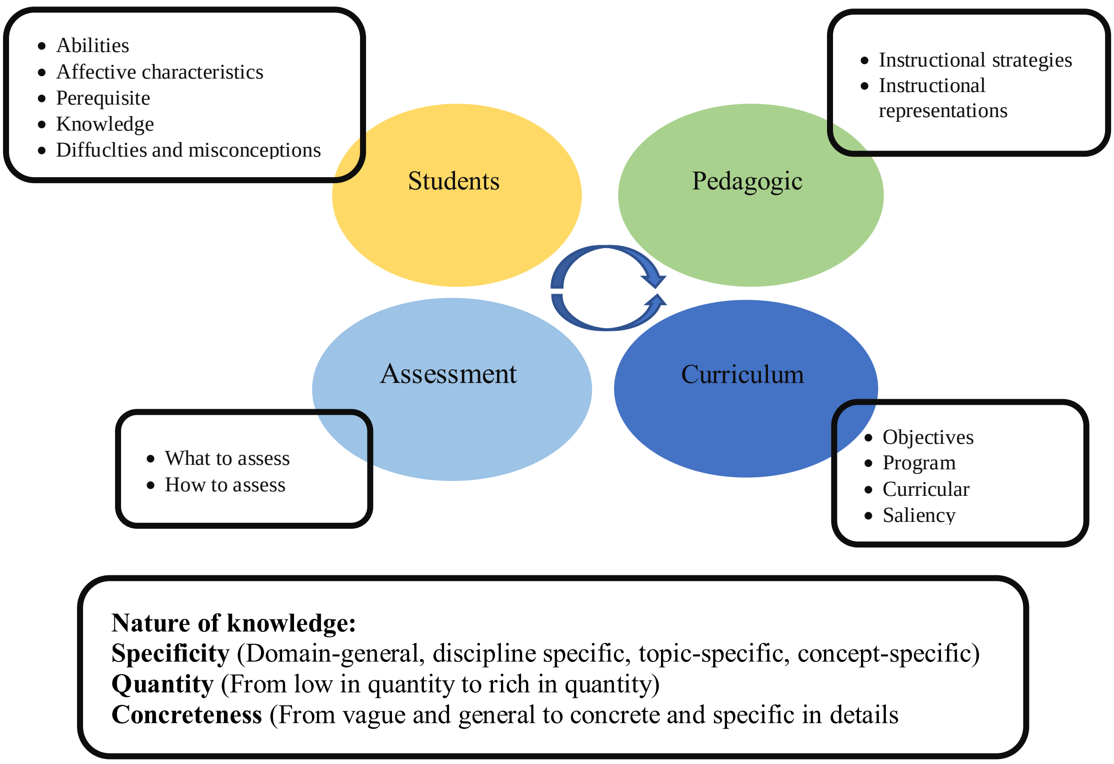

Figure 2: Teacher knowledge for effective STEM teaching

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

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).

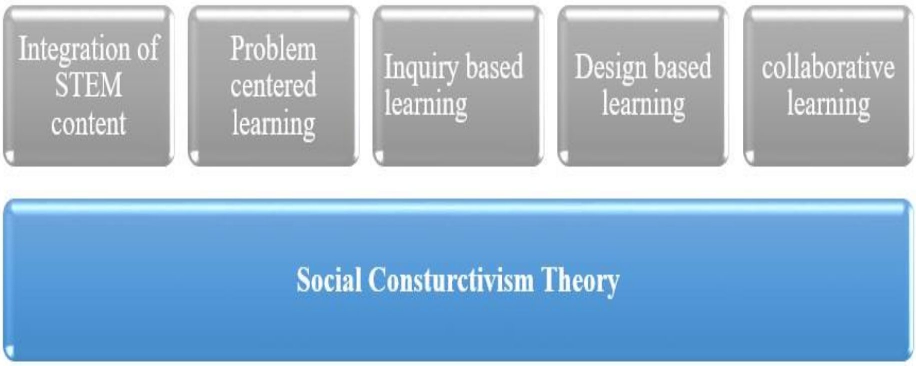

Figure 3: Theoretical framework for STEM education

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).

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).

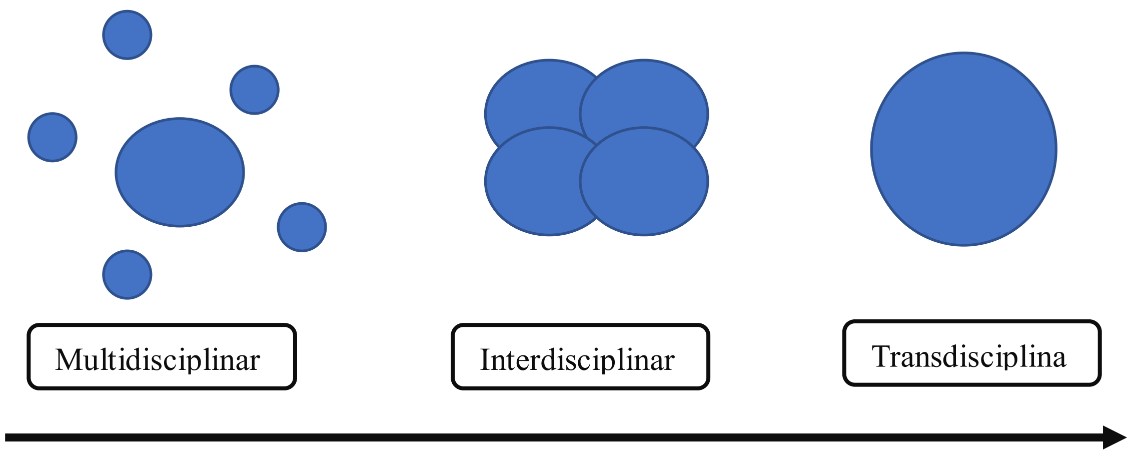

Figure 4: Continuum of Integration.

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).

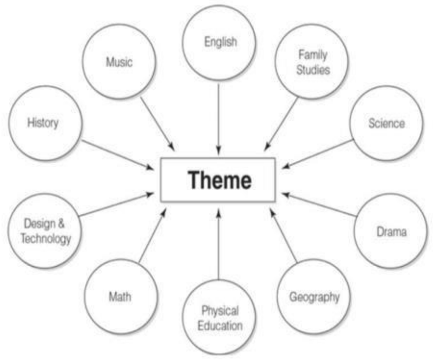

Figure 5: Multidisciplinary approach

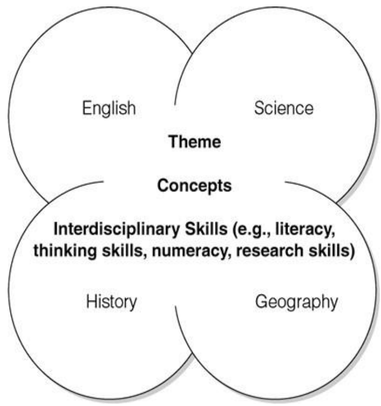

Figure 6: Interdisciplinary

Figure 7: Transdisciplinary approach

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 projectbased 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).

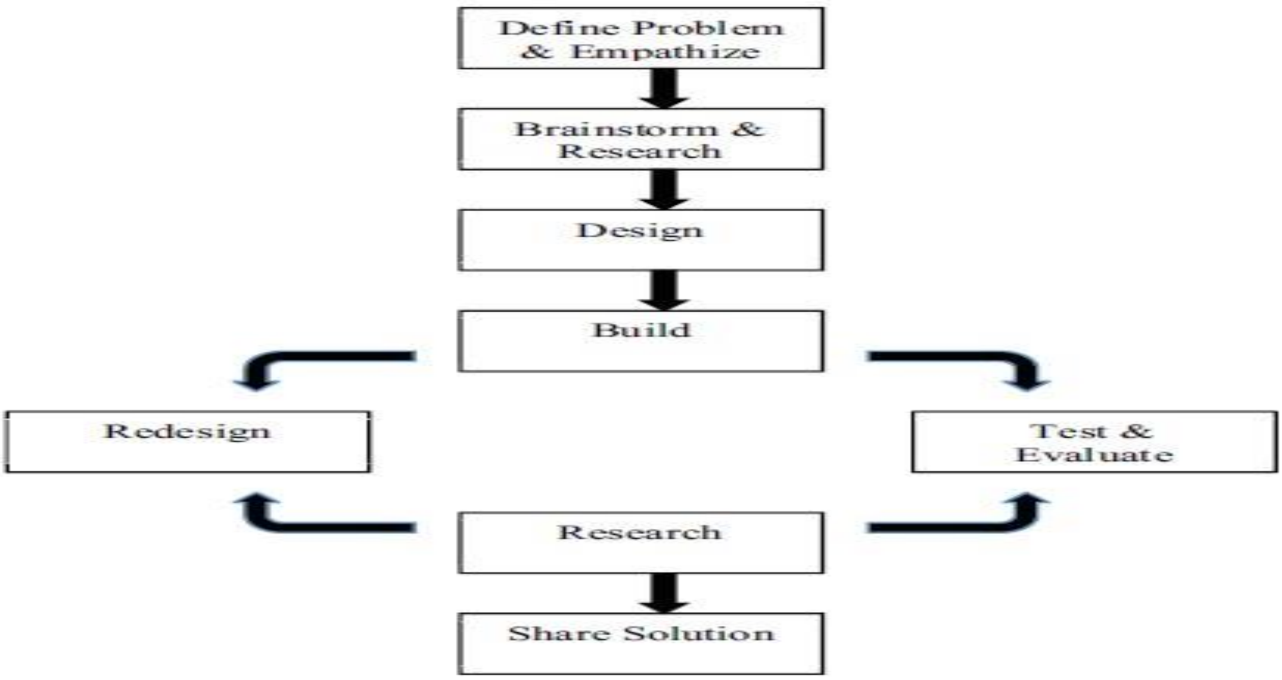

Figure 8: Engineering design process.

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.

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 Primary Curriculum

Several recommendations from STEM education literature reported that learning STEM should start at Primary 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 Primary 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).

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

Additionally, science is a dynamic and collaborative human endeavor with links with other subjects and cross-cutting issues. 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 (*Primary School 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 (*Primary School 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 (*Primary School Curriculum*, 2018). However, it is worth mentioning that STEM was not stated in the curriculum standards of Primary stage.

STEM Education in Cameroon

In recent decades, Science, Technology, Engineering, and Mathematics (STEM) education has gained global attention as a critical driver of economic development and innovation. Cameroon, like many other countries, has recognized the importance of STEM education in preparing its youth for the challenges and opportunities of the 21st century. This literature review provides an overview of the current state of STEM education in Cameroon, highlighting key trends, challenges, and initiatives.

The introduction of STEM education in Cameroon can be traced back to the country's commitment to achieving the objectives set by the World Declaration on Education for All in 1990. The government's acknowledgment of the need to align education with the demands of the modern workforce laid the foundation for the integration of STEM subjects into the national curriculum (Tchombe, 2007). While strides have been made, the literature suggests that challenges persist in fully implementing and optimizing STEM education in Cameroon.

STEM education in Cameroon operates within the framework of the national education system, guided by policies and curriculum structures. The Cameroon government has taken steps to integrate STEM subjects into primary and secondary education, recognizing their role in fostering critical thinking and problem-solving skills (NACA, 2019). However, scholars point out that there is a need for ongoing policy adjustments to address emerging challenges and align STEM education with industry needs (Epoh, 2016).

Central to the success of STEM education is the preparedness of teachers to deliver effective and engaging instruction. Research suggests that many Cameroonian teachers face challenges in adapting their pedagogical approaches to the interdisciplinary nature of STEM (Mengu, 2018). The need for continuous professional development programs tailored to STEM educators is emphasized as a crucial component for enhancing teaching methods and content delivery (Nji & Epoh, 2015).

The literature highlights significant disparities in infrastructure and resources among schools in urban and rural areas. Access to laboratories, technological equipment, and updated teaching materials is often limited in rural schools, impacting the quality of STEM education (Achuonye, 2014). Addressing these disparities is crucial for ensuring equitable opportunities for all students to engage in meaningful STEM learning experiences.

Gender disparities persist in STEM education in Cameroon, mirroring global trends. Studies indicate that girls are underrepresented in STEM fields, partly due to societal expectations and stereotypes (Mukam, 2017). Addressing gender disparities in STEM education requires targeted interventions, including awareness campaigns, mentorship programs, and initiatives to challenge gender stereotypes (Ndombo, 2018).

Collaboration between academic institutions and industry is essential for aligning STEM education with the evolving needs of the job market. While some partnerships exist, the literature suggests that there is room for increased collaboration between schools, universities, and industry stakeholders to bridge the gap between education and employment (Epie & Epah, 2019).

Despite the challenges, there are positive initiatives and success stories in STEM education in Cameroon. Various organizations, both governmental and non-governmental, have implemented programs to promote STEM awareness, provide scholarships, and support innovative projects (Nkwe, 2016). These initiatives serve as valuable models for effective STEM education implementation.

As Cameroon strives to strengthen its STEM education landscape, challenges such as limited funding, curriculum alignment, and teacher professional development need ongoing attention. However, there are also opportunities to leverage advancements in technology, international collaborations, and innovative teaching methods to enhance STEM education across the country (Epoh & Wepngong, 2020).

In conclusion, this literature review provides a comprehensive overview of the current state of STEM education in Cameroon. While significant progress has been made, challenges persist, and there is a need for sustained efforts to address infrastructure gaps, enhance teacher preparedness, and promote gender inclusivity. As Cameroon navigates the evolving landscape of STEM education, continuous research, policy adjustments, and collaborative initiatives will be crucial for ensuring that the country's youth are well-equipped to contribute to the global knowledge economy.

Review by Objectives

This review synthesizes research findings and insights from various sources to provide a thorough understanding of the state of knowledge in the field.

Objective 1: To assess science teachers' knowledge of STEM education.

Science, Technology, Engineering, and Mathematics (STEM) education has gained significant attention in recent years as a means to prepare students for an increasingly complex and technology-driven world. Science teachers play a crucial role in delivering STEM education, as they are responsible for imparting foundational knowledge and skills. This literature review examines the existing research on science teachers' knowledge of STEM education, focusing on their preparedness, professional development, and the impact of their knowledge on student outcomes.

Science Teachers' Preparedness for STEM Education

Science teachers are often expected to integrate STEM principles into their teaching practices. Several studies have found that many teachers feel ill-prepared for this task. In a study by Smith et al. (2016), it was found that a significant number of science teachers lacked the necessary content knowledge in engineering and technology, hindering their ability to teach STEM effectively. Jones and Shelton (2017) highlighted that teachers often struggle with interdisciplinary connections and the application of mathematical concepts within science lessons.

Professional Development and Teacher Training

The need for professional development programs to enhance science teachers' knowledge and skills in STEM education is well-documented. Bybee (2013) advocated for teacher training programs that provide teachers with hands-on STEM experiences and collaborative learning opportunities. National Research Council (NRC) (2014) stressed the importance of professional development that is aligned with the Next Generation Science Standards (NGSS) and focuses on inquiry-based teaching methods.

The Impact of Science Teachers' STEM Knowledge on Student Outcomes

A growing body of research suggests that science teachers with a strong understanding of STEM education have a positive impact on student learning. Hanuscin et al. (2016) conducted a study showing that science teachers who were well-versed in STEM practices were more successful in fostering students' problem-solving skills and scientific literacy. Wang et al. (2018) found a correlation between science teachers' confidence in teaching STEM and students' increased interest in STEM-related careers.

Barriers and Challenges Faced by Science Teachers

Several barriers hinder science teachers' ability to acquire and implement STEM knowledge effectively. In their research, Anderson et al. (2019) identified a lack of time and resources as a significant challenge for science teachers aiming to integrate STEM into their classrooms. Koomen and Stevenson (2015) reported that science teachers face resistance from students and parents when they shift from traditional teaching methods to more interactive and inquiry-based STEM approaches.

Science teachers' knowledge of STEM education is a critical factor in the success of STEM initiatives. While there is a growing recognition of the importance of STEM integration, many science teachers remain ill-prepared. Professional development and training programs can help bridge this knowledge gap, and research indicates that when science teachers are equipped with strong STEM knowledge, it positively impacts student outcomes. However, significant challenges and barriers persist in the integration of STEM education in science classrooms, underscoring the need for continued research and support for educators in this endeavor.

Objective 2: To determine the teaching methods for effective STEM education.

Effective STEM education requires a pedagogical shift from traditional subject-based teaching to an interdisciplinary, inquiry-based approach. Research indicates that successful STEM education programs incorporate project-based learning, problem-solving activities, and hands-on experiences. These teaching requirements encourage students to explore real-world issues, fostering critical thinking, creativity, and collaboration.

STEM education is of paramount importance in the 21st century, as it underpins technological advancements and drives innovation. Effective teaching methods are crucial for fostering interest, engagement, and proficiency in STEM disciplines among students of all ages. To elucidate the diverse array of teaching methods, this literature review is organized into the following sections:

Pedagogical Approaches

Inquiry-Based Learning:

Inquiry-based learning promotes active student engagement by encouraging them to ask questions, explore topics, and conduct investigations. Several studies (Banchi & Bell, 2008) have shown that this method enhances critical thinking and problem-solving skills.

Project-Based Learning (PBL):

PBL emphasizes hands-on, real-world problem-solving. Research (Hmelo-Silver, 2004) suggests that PBL increases motivation and long-term knowledge retention in STEM subjects.

Flipped Classroom:

Flipping the classroom involves moving lectures and content delivery outside of class time, allowing in-class time for interactive activities. Recent studies (Strayer, 2012) show that this approach can improve student performance and engagement.

Assessment Methods

Formative Assessment:

Formative assessment techniques such as quizzes, concept maps, and peer evaluations are useful for providing immediate feedback and guiding instruction. Black and Wiliam (1998) conducted a landmark study showing the benefits of formative assessment in improving student learning outcomes.

Authentic Assessment:

Authentic assessments, such as real-world projects and problem-solving tasks, gauge students' abilities to apply their knowledge. They have been shown to be effective in measuring STEM competency (Herrington & Herrington, 2006).

Rubrics and Self-Assessment:

The use of rubrics and self-assessment encourages students to take ownership of their learning. Research (Andrade, 2005) indicates that these tools can improve student performance and self-regulation.

Technology in STEM Education

Virtual Laboratories:

Virtual labs provide a cost-effective and accessible means for students to conduct experiments and explore scientific phenomena. Studies (Haciyakupoglu & Yildirim, 2012) have demonstrated the efficacy of virtual labs in enhancing STEM learning.

Online Learning Platforms:

The integration of online platforms, such as Khan Academy and Coursera, has opened up opportunities for self-paced learning and personalized instruction. Various studies (Means et al., 2014) highlight the benefits of online learning in STEM education.

Interactive Simulations:

Interactive simulations and educational games can engage students and facilitate experiential learning. Research (Squire & Jenkins, 2003) suggests that these tools can enhance problem-solving and conceptual understanding.

Inclusivity in STEM Education

Diversity and Inclusion:

To address disparities in STEM, strategies that promote diversity and inclusivity have gained prominence. Research (Smith et al., 2016) indicates that fostering an inclusive classroom environment can improve outcomes for underrepresented groups.

Gender Equity:

Efforts to promote gender equity in STEM have led to research on strategies to reduce the gender gap. Studies (Hill et al., 2010) show that interventions like mentorship and role models can positively impact female students' STEM engagement.

A study by Stohlmann, Moore, and Roehrig (2012) identified specific teaching strategies that are effective in STEM classrooms. These include promoting student autonomy, providing opportunities for student-led inquiry, and fostering a growth mindset. Moreover, effective STEM teachers often collaborate with professionals in STEM fields to bring real-world context into the classroom, making the content more engaging and relevant for students.

Effective teaching methods in STEM education encompass a wide range of pedagogical approaches, assessment methods, and technological tools. The literature suggests that a combination of these strategies, tailored to the specific needs of students and instructors, can yield the best results. Additionally, fostering inclusivity in STEM education is essential for addressing disparities and ensuring that all students have the opportunity to excel in these critical fields. Ongoing research will continue to refine and expand our understanding of effective teaching methods in STEM education, helping to prepare the next generation of scientists, engineers, and mathematicians.

Objective 3: To evaluate the impact of STEM education on students' outcomes.

The impact of STEM education on students' outcomes has been the focus of numerous research studies. Several of these studies have found a positive correlation between STEM education and improved academic performance. Students exposed to STEM education tend to develop problem-solving skills, critical thinking abilities, and a deeper understanding of STEM concepts.

Academic Achievement

Sanders, M. (2009). "STEM, STEM Education, STEMmania." American Society for Engineering Education.

Sanders emphasizes the importance of STEM education in improving students' academic achievement. STEM programs tend to enhance students' problem-solving abilities and critical thinking, ultimately leading to improved performance in science and mathematics.

Pellegrino, J. W., & Hilton, M. L. (2012). "Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century." National Academies Press.

This report highlights the role of STEM education in developing cognitive skills, particularly critical thinking and problem-solving, which are transferable across various academic disciplines.

Riegle-Crumb, C., & King, B. (2010). "Questioning a White Male Advantage in STEM: Examining Disparities in College Major by Gender and Race/Ethnicity." Educational Researcher.

Riegle-Crumb and King's research suggests that STEM education can contribute to reducing gender and racial disparities in academic achievement, particularly in science and mathematics.

Career Readiness

Bybee, R. W. (2013). "The Case for STEM Education: Challenges and Opportunities." NSTA Press.

Bybee underscores the connection between STEM education and career readiness. He argues that STEM skills are in high demand across various industries and that STEM education can prepare students for successful careers.

National Academy of Engineering & National Research Council. (2014). "STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research." National Academies Press.

This report discusses the importance of integrating STEM education into K-12 curricula and highlights its positive impact on students' career prospects by fostering innovation and problem-solving skills.

Broader Skills Development

NGSS Lead States. (2013). "Next Generation Science Standards: For States, By States." National Academies Press.

The Next Generation Science Standards emphasize the importance of developing skills such as communication, collaboration, and critical thinking, in addition to content knowledge, which are central to STEM education.

Moore, T. J., Stohl, H., Wang, H. H., Tank, K. M., & Roehrig, G. H. (2014). "Implementation and Integration of Engineering in K-12 STEM Education." Journal of Pre-College Engineering Education Research.

Moore et al. discuss the integration of engineering within STEM education, noting its contribution to students' problem-solving and design thinking skills.

Research by Ritz, Fan, and Mayberry (2018) demonstrated that students engaged in STEM education not only perform better in STEM subjects but also show improved performance in non-STEM areas. Furthermore, STEM education is associated with increased interest and participation in STEM-related careers, addressing the growing demand for a STEM-skilled workforce.

The reviewed literature demonstrates the positive impact of STEM education on students' outcomes. STEM education is associated with improved academic achievement, increased career readiness, and the development of essential skills for the 21st century. As we move forward, it is essential to continue research in this area and refine STEM education strategies to better prepare students for the demands of an increasingly technology-driven world.

Objective 4: To identify challenges that may hinder the implementation of STEM education.

The implementation of STEM education is not without its challenges. Several factors have been identified that can hinder the successful integration of STEM in schools. One key challenge is the lack of teacher preparation and professional development opportunities, which can result in teachers feeling ill-equipped to deliver integrated STEM lessons effectively. Resource constraints, such as inadequate funding for STEM materials and technology, also hinder implementation. Research by Banilower, Smith, Weiss, Malzahn, and Campbell (2013) highlights the importance of sufficient resources and support structures to facilitate STEM education. Additionally, societal stereotypes and biases can discourage underrepresented groups, particularly women and minorities, from pursuing STEM fields, making it essential to address these barriers in STEM education.

Lack of Qualified STEM Educators

One of the most fundamental challenges in STEM education is the shortage of qualified educators. A study by Ingersoll and Strong (2011) highlights that many teachers lack the subject-matter expertise needed to effectively teach STEM subjects. This is further exacerbated by the need for ongoing professional development (Desimone, 2009) to keep pace with rapidly evolving fields.

Gender and Diversity Gaps

Gender and diversity gaps persist in STEM education and careers. Research by Diekman et al. (2011) and Stout et al. (2011) emphasizes the underrepresentation of women and minority groups in STEM fields. These disparities can be traced back to early education and are a significant challenge to equitable STEM implementation.

Curriculum and Pedagogy Challenges

The STEM curriculum is often criticized for being too rigid and theoretical, leading to disengagement among students. Research by Bybee (2013) and Chittum (2013) calls for more practical, hands-on learning experiences and cross-disciplinary approaches to teaching STEM subjects.

Resource Constraints

Many educational institutions, particularly in underserved communities, face resource constraints. Lack of funding for laboratory equipment, technology, and materials hampers the quality of STEM education (National Academy of Engineering, 2010). This, in turn, impacts the overall effectiveness of STEM implementation.

Standardized Testing and Accountability Pressures

High-stakes standardized testing can lead to a narrow focus on test preparation, which may hinder innovative teaching methods (Smith & Jones, 2010). The pressure to meet accountability measures can deter educators from adopting experiential and inquiry-based STEM approaches.

Attitudes and Perceptions

Public attitudes and perceptions towards STEM can hinder its implementation. Negative stereotypes about STEM being difficult or uninteresting can discourage students from pursuing STEM subjects (Archer et al., 2010). Additionally, parents' and teachers' attitudes play a significant role in shaping students' interest in STEM (Archer et al., 2013).

Alignment with Workforce Needs

Ensuring that STEM education aligns with workforce needs and industry demands is a persistent challenge (Bybee, 2010). Rapid technological advancements require agile curricular adjustments, making it challenging for educational institutions to stay up-to-date.

Accessibility and Inclusivity

Accessibility to STEM education, particularly in remote and rural areas, remains a concern. Research by Ritz and Fan (2015) highlights the importance of expanding access to STEM education to underserved communities to bridge the opportunity gap.

Resistance to Change

Implementing innovative STEM education approaches often faces resistance from traditional teaching methods and institutional inertia (Henriquez & Riconscente, 2015). The change management process in educational institutions can be slow and challenging.

Assessment and Evaluation

Designing effective assessment and evaluation methods in STEM education that go beyond traditional testing can be challenging (Dori & Belcher, 2010). Measuring skills, problem-solving abilities, and the application of knowledge is complex but essential for a comprehensive STEM education approach.

In conclusion, STEM education is a dynamic and transformative approach that holds the potential to equip students with the skills and knowledge needed to thrive in the 21st century. This comprehensive literature review underscores the importance of teacher knowledge, effective teaching strategies, positive student outcomes, and the need to address challenges in implementing STEM education. Continued research and investment in STEM education are crucial to unlock its full potential and ensure a workforce that can tackle the complex challenges of the modern world.

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 Mezam Division. Moreover, this chapter will include the research design, population, sampling, pilot studies and ethical considerations

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).

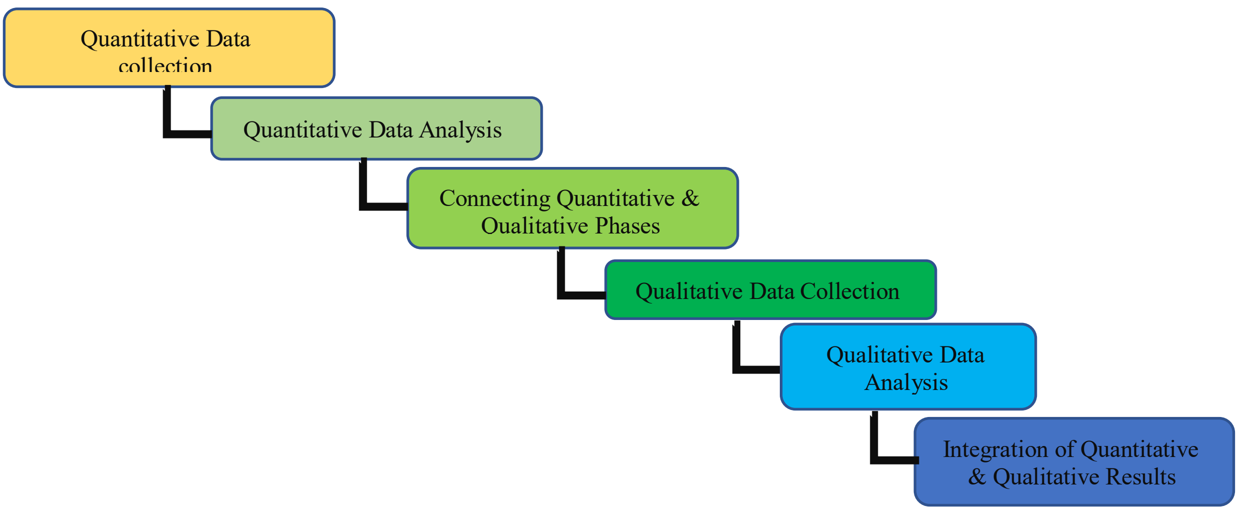

Figure 9: Explanatory sequential mixed method design

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

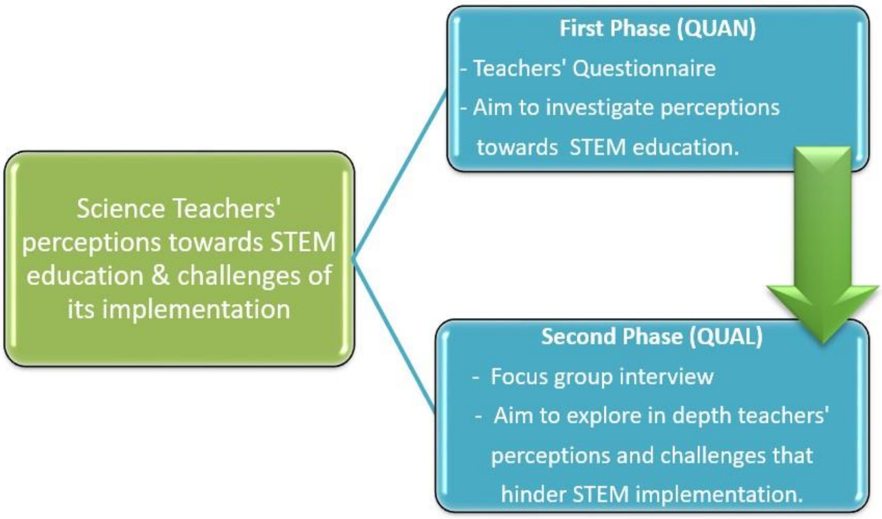

Figure 10: Design of the research method and data collection

Research Context and Respondents

Targeted Population

The current study targets science teachers working in public primary schools of Mezam Division during the academic year 2022-2023. 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 Mezam Division, despite the fact that the number of primary schools represent around 37% of total public primary schools in Mezam Division (Planning and Statistics Authority, 2022). Moreover, according to the latest MINEDUB records for the current academic year (2022-2023), there are (412) science teaches on the job within public primary schools in the state of Mezam Division (Teachers Affairs Office). Those teachers represent 6.15% of total number of teachers in public primary schools. 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).

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 Mezam Division 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 to science teacher's groups; in order to gather as many responses as possible. The survey was open from 19th of September 2023 till 10th of November 2023. The researcher received (148) responses, which represents approximately 36% of total science teachers in public primary schools in Mezam Division. 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 (Mezam Division 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).

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 Mezam Division. The demographic data of the respondents is included in the first section of the questionnaire (Appendix 1). 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	CAPIEMP	117	79.1%
	Higher Diploma	11	7.4%
	Bachelor degree	19	12.8%
	Master degree	1	0.7%
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 %
Have you ever received any STEM related professional development training?	Yes No	60 88	40.5 % 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 %

This table summarizes the frequencies and percentages of various demographic categories among the survey respondents. It provides insights into the gender distribution, educational background, teaching experience, participation in STEM professional development training, experience in teaching STEM lessons, and the methods through which STEM is being taught/offered in respondents' schools.

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 teacher hold doctoral degree (0.7%). (47%) of the respondents got their highest degree from Mezam Division while (53%) got it from another Regions.

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 Bamenda1, followed by (48%) in Bamenda 2

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.

Focus group respondents

In addition to their years of experience (6 to 15 years or more) of teaching in Mezam Division 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	Bamenda1
	F2	Female	6 years	Bamenda 1
	F3	Female	12 years	Bamenda 1
2	H4	Female	7 years	Bamenda 2
	H5	Female	15 years	Bamenda 2
	H6	Female	10 years	Bamenda 2
3	M7	Male	11 years	Bamenda 1
	M8	Male	17 years	Bamenda 1
	M9	Male	14 years	Bamenda 1
4	I10	Female	13 years	Bamenda 2
	I11	Female	18 years	Bamenda 2
	I12	Female	9 years	Bamenda 2

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.

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 Mezam Division public schools.

The first domain: Teachers' perceptions about STEM education's knowledge. It consists of fourteen items (9-22). 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 23-33). 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 (34 – 41), 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 (42 -49) describing and examining the challenges that might hinder STEM implementation in science classes. The last item (50) is an open-ended question about further challenges that might face teachers and hinder STEM implementation in their science classes.

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 lecturers from the University of Yaounde I, in addition to four professional development specialists (Math & Science specialty). 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

Teachers' Focus groups Interview

The focus group interviews serve as the qualitative data collection phase of the study, allowing for a deeper exploration of science teachers' familiarity and perceptions regarding STEM implementation, as well as the identification of key factors that may hinder its implementation in science classes in public primary schools. The protocol for the focus group interviews was adapted from El-Deghaidy & Mansour (2015), and the final set of questions was developed based on the findings from the survey.

Following the guidelines outlined by Cohen et al. (2018), the dynamics of participant interaction within the focus groups are crucial as they contribute to the collective understanding of the study topic. Each focus group consisted of three participants, totaling four focus groups

(N=4). Participants who agreed to be interviewed were provided with a consent form to sign and return via email.

The focus group questions were carefully crafted to encourage open discussion and exploration of participants' perspectives, experiences, and insights related to STEM implementation in public primary school science classes. Through these interviews, the study aims to capture rich qualitative data that complements and enriches the findings obtained from the survey phase of the research.

Research Procedures

This study was executed at public primary schools in Mezam Division during academic year 2022 - 2023. Prior the study implementation, the researcher obtained clearance from MINEDUB in addition to the clearance from the Review Board Department at Mezam Division University.

This approval required filling application and checklist forms in addition to attaching all the required documents (MINEDUB approval, Researcher Authorization letter from the Dean of the Faculty of Education, the instruments (survey and focus group interview), and a consent form for both instruments and the proposal of the study. All the previously listed documents and forms were taken to Divisional Delegation for Basic Education for Mezam Division. Succeeding, the ethical approval was sent from department after reviewing all the requirements and forms, (Appendix 1).

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 the Faculty of Education, 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 Mezam Division, 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 face to face. Each focus group

interview lasted from 25-35 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.

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.

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 MINEDUB (Ministry of Education and Higher Education). Furthermore, the structure of the 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 Mezam Division. 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 reflect 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 Mezam Division 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

What are science teachers' perceptions towards STEM education in public primary schools in Mezam Division?

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

Teachers' perceptions of STEM education knowledge.

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

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 are 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
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

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, 21stcentury 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."
		- "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."
Similarity	STEM Instructional practices	- "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."

Teachers' perceptions of STEM teaching requirements.

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

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

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 MINEDUB 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 MINEDUB 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."
Similarity	STEM teaching requirements related to Stakeholders	- "Stakeholders' awareness in MINEDUB of STEM." - "Training of the supervisors and specialists from MINEDUB." - "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.”

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 Mezam Division public primary schools

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

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."
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 improves 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 depend 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."

Teachers' perceptions of the challenges facing STEM implementation.

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

Quantitative Results (Survey)

The last domain of the survey covers eight statements related to the challenges that hinder STEM implementation in Mezam Division 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

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, Mezam Division University Exxon Mobil teacher's academy is the only program that present this topic."
	"In my school, I am the only one that attend STEM training program."
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 school's restriction."
	"Supervisors are evaluating students' outcome by evaluating content only not skills."
	"There is no consistency between MINEDUB supervisors"
	"Distress from MINEDUB, there is no flexibility and enough space for teachers."
	"Accountability from MINEDUB Supervisors has no unified rules."

Section Two: Variances Analysis

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

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 pvalues 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 Male	130 18	4.0813 4.1032	0.1612	-0.1356	0.892
Teachers' perceptions of STEM teaching requirements.	Female Male	130 18	4.0958 4.2778	0.1526	-1.1926	0.235
Teachers' perceptions of the impact of STEM education on students' outcomes.	Female Male	130 18	4.0885 4.1597	0.1563	-0.4558	0.649
Teachers' perceptions of the challenges facing STEM implementation	Female Male	130 18	3.9750 4.0694	0.1501	-0.6291	0.530

Teachers' perceptions of STEM education according to Educational Background

The original educational background variable has four categories (CAPIEMP –

Higher Diploma – Bachelor – Master) recall table (16) of frequencies:

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

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

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

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

Educational Background	Frequency	Percentage
CAPIEMP	117	79.1
Graduates (Higher Diploma – Bachelor– Master)	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 CAPIEMP and teachers with 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	CAPIEMP Grad	117 31	4.0794 4.1014	0.129	-0.170	0.865
Teachers' perceptions of STEM teaching requirements.	CAPIEMP Grad	117 31	4.1080 4.1554	0.123	-0.385	0.701
Teachers' perceptions of the impact of STEM education on students' outcomes.	CAPIEMP Grad	117 31	4.0972 4.0968	0.126	0.004	0.997
Teachers' perceptions of the challenges facing STEM implementation	CAPIEMP Grad	117 31	3.9904 3.9718	0.121	0.154	0.878

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		
	From 6 to 10 years	43	4.1711		
	From 11 to 15 years	50	4.1114	1.923	0.129
	16 years or more	38	3.8816		
	Total	148	4.0840		
Teachers' perceptions towards STEM teaching requirements.	Less than 5 years	17	4.2995		
	From 6 to 10 years	43	4.1522		
	From 11 to 15 years	50	4.1364	1.288	0.281
	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 From 6 to 10 years From 11 to 15 years	17 43 50	4.3456 4.1366 4.1050	1.917	0.129
	16 years or more	38	3.9309		
	Total	148	4.0971		
Teachers' perceptions about the challenges facing STEM years implementation	Less than 5 years	17	4.2574	3.694	0.013
	From 6 to 10	43	3.9709		
From 11 to 15 years	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 From 11 to 15 years 16 years or more	0.481 0.294 0.841
From 6 to 10 years	Less than 5 years From 11 to 15 years 16 years or more	- 0.481 - 0.187 0.360
From 11 to 15 years	Less than 5 years From 6 to 10 years 16 years or more	-0.294 0.187 0.547
16 years or more	Less than 5 years From 6 to 10 years From 11 to 15 years	-0.841 -0.360 -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.

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 pvalue 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 relate 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 Yes	88 60	3.9253 4.3167	0.102	-3.825	0.000	0.613
Teachers' perceptions towards STEM teaching requirements.	No Yes	88 60	3.9752 4.3273	0.098	-3.599	0.000	0.579
Teachers' perceptions towards the impact of STEM education on students' outcomes.	No Yes	88 60	3.9716 4.2813	0.101	-3.068	0.003	0.500
Teachers' perceptions about the challenges facing STEM implementation	No Yes	88 60	3.9503 4.0396	0.100	-0.895	0.372	0.150

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 Yes	95 53	3.9526 4.3194	0.105611	-3.473	0.001	0.574
Teachers' perceptions of STEM teaching requirements.	No Yes	95 53	3.9952 4.3379	0.100609	-3.406	0.001	0.564
Teachers' perceptions of the impact of STEM education on students' outcomes.	No Yes	95 53	3.9855 4.2972	0.103483	-3.012	0.003	0.503
Teachers' perceptions of the challenges facing STEM implementation	No Yes	95 53	3.9408 4.0684	0.101931	-1.252	0.213	0.214

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 relate 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 Mezam Division 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.

What are science teachers' perceptions towards STEM education in public primary schools in Mezam Division?

Data collected to answer the first question indicate that science teachers in primary public schools in Mezam Division 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.

What are the science teachers' perceptions of STEM education knowledge in Mezam Division 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 reallife 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. 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 oppose Madani (2020) study results, which pointed out teachers' imprecision in explaining the main instructional practices of STEM.

What are the science teachers' perceptions of STEM teaching requirements in Mezam Division 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 MINEDUB 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.

What are science teachers' perceptions of the impact of STEM education on students' outcomes in Mezam Division 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' 21^{st} 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 are 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 these disciplines to STEM is the prominence of the literacy skills for effective implementation of integrated curriculum that requires critical thinking and creativity skills.

What are the science teachers' perceptions of the challenges facing STEM implementation in Mezam Division 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 MINEDUB
Supervisors who have no unified rules" and "no consistency between MINEDUB 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 enforce STEM implementation in primary public schools in Mezam Division. These findings have important implications in providing STEM teaching requirements, improving teachers' awareness, understanding, and practices, and establishing effective professional development programs.

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 objectives 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 MINEDUB changed their teaching policy since 2017. They start hiring male teachers for teaching Primary 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 MINEDUB 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.

CONCLUSION

The current study has investigated science teachers' perceptions towards STEM education in primary public schools in the State of Mezam Division. 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 Mezam Division 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 were 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 Mezam Division 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.

RECOMMENDATIONS

Guided by the results of this study, the researcher recommends that the MINEDUB provides science teachers with additional effective STEM professional development programs prepared. Moreover, developing STEM integrated curriculum and flexible semester plans compatible with the implementation of STEM education by the MINEDUB 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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APPENDIXES

Appendix 1: Questionnaire

UNIVERSITE DE YAOUNDE I
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FACULTE DES SCIENCES DE L'EDUCATION
******
CENTRE DE RECHERCHE EN SCIENCES SOCIALES ET EDUCATIVES

THE UNIVERSITY OF YAOUNDE I
******
FACULTY OF SCIENCES OF EDUCATION
******
POST GRADUATE SCHOOL FOR SOCIAL AND EDUCATIONAL SCIENCES
******

QUESTIONNAIRE

Dear Teachers,

I am Tia Tchouola Nina from the University of Yaounde 1, Faculty of Education, Department of Curriculum Development and Evaluation. This survey investigates "**TEACHERS' PERCEPTIONS TOWARD STEM (science, technology, engineering and mathematics) EDUCATION AND CHALLENGES OF ITS IMPLEMENTATION IN SELECTED PRIMARY SCHOOLS IN MEZAM DIVISION".** All information will be used for the academic research only and will be held in strict confidentiality. Accordingly, please answer all the following questions to the best of your knowledge. By completing this survey, you give your concern to participate in this study.

Instruction: Tick ☑ the correct answer from the alternatives.

I. Demographic Data

<table>
<tr><td>1. Gender</td><td colspan="2">Male</td><td colspan="3">Female</td></tr>
<tr><td>2. Educational background</td><td>Bachelor</td><td>Higher Diploma</td><td>Masters</td><td>Doctoral</td><td>Others</td></tr>
<tr><td>3. Teaching experience</td><td>Less than 5 years</td><td>6-10 years</td><td>11-15 years</td><td colspan="2">16 years and more</td></tr>
<tr><td>4. Specialty</td><td colspan="5"></td></tr>
<tr><td>5. School location</td><td colspan="2">Bamenda I</td><td colspan="3">Bamenda II</td></tr>
<tr><td>6. Have you ever received any STEM related training?</td><td colspan="2">Yes</td><td colspan="3">No</td></tr>
<tr><td>7. Have you taught STEM lessons?</td><td colspan="2">Yes</td><td colspan="3">No</td></tr>
<tr><td>8. How is STEM being taught or offer in your school?</td><td>Extracurricular activities</td><td colspan="2">After school programs</td><td colspan="2">Regular curriculum</td></tr>
</table>

II. Survey

Please respond to the following questions related to STEM education. In this questionnaire, there is no right or wrong answers. Please give your opinions and choose only one answer. Our thoughtful and candid respone are greatly appreciated.

1. **Teachers' perceptions of STEM educational knowledge.**

To what extend do you agree or disagree with the following statements related to STEM education?						
No.	**Statements**	**Response**				
		Strongly agree	**Agree**	**Neutral**	**Strongly disagree**	**Disagree**
9	The concept of stem education is defined as teaching the knowledge, skills, and logical thinking related STEM career.					
10	STEM education is a connection between subjects within authentic context to enhance students' learning					
11	Teachers can optionally combine science, engineering, technology and mathematic.					
12	Scientific inquiry and Engineering design are two main themes in a STEM lesson.					
13	The term "technology" in STEM is NOT solely restricted to the use of technology in the classroom, such as computers, projects, and cameras.					
14	STEM helps in connecting scientific concepts and knowledge in an interdisciplinary paradigm.					
15	STEM helps students build scientific explanations and evaluate solutions.					
16	STEM enhances students thinking to					

	generate innovative solutions to real life problems.					
17	Problem based learning is an important element in teaching STEM.					
18	STEM aims at linking knowledge to global problems such as global warming and saving energy.					
19	STEM allows the diversity of educational context through multiplicity of educational outcomes					
20	STEM employs a variety of strategies to solve scientific problems with flexibility.					
21	STEM removes barriers between subjects and provides flexibility upon integrating new information.					
22	STEM allows using different methods and approaches to achieve tasks.					

2. **Teachers' perceptions of STEM teaching requirements.**

To what extend do you agree or disagree with the following statements about STEM teaching requirements?						
No.	**Statements**	**Response**				
		strongly agree	**Agree**	**Neutral**	**Strongly disagree**	**Disagree**
23	Teaching STEM requires employing mathematical operations in scientific topics.					
24	Teaching STEM requires using inquiry based learning.					
25	Teaching STEM requires enhancing students' acquisition of communication skills while handling STEM tasks.					
26	Teaching STEM requires training					

	students on engineering design.					
27	Teaching STEM requires engaging students in evidence based discussion.					
28	Teaching STEM requires raising curiosity about natural phenomenal and scientific discoveries.					
29	Teaching STEM requires interpreting two or more of STEM fields within one lesson.					
30	Teaching STEM requires training students to search and investigate using various reliable resources from different disciplines.					
31	Teaching STEM requires enhancing students' abilities to solve problems and scientific thinking.					
32	Teaching STEM requires using technology to integrate multiple STEM fields.					
33	Teaching STEM requires making decisions based on data to understand how to refine ideas further.					

3. Teachers' perceptions toward the impact of STEM education on students' outcome.

To what extent do you agree or disagree with the following statements regarding the impact of STEM education on students' outcomes?						
No.	**Statements**	**Response**				
		Strongly agree	**Agree**	**Neutral**	**Strongly Disagree**	**Disagree**
34	STEM helps students acquire skills related directly to STEM careers.					
35	STEM helps students acquire critical thinking skills and use of data driven evidence.					
36	STEM help students acquire authentic problem-solving skills to help in making decisions in real life situations.					
37	STEM helps students leverage collaborative learning to execute STEM learning projects.					
38	STEM helps students acquire engineering abilities (define the needs, design, and make a certain product) to make beneficial products,					
39	STEM prepares students for international standardized assessment such as PISA and TIMSS.					
40	STEM has a positive impact on developing students' creativity.					
41	STEM helps students acquire decision-making skills.					

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

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?						
No.	**Statements**	**Response**				
		Strongly agree	**Agree**	**Neutral**	**Strongly disagree**	**Disagree**
42	Searching and finding an idea to conduct STEM activities.					
43	A need for knowledge enhancement beyond your major, related to STEM subfields.					
44	How to conduct formative assessment for students' achievement in STEM lessons.					
45	Finding extra time for students to conduct STEM lessons.					
46	Materials and equipment used in STEM lessons are expensive.					
47	The required experience of teachers in their fields for effective STEM implementation.					
48	Engaging all students in large classrooms.					
49	The insufficient of STEM professional development programs for teachers					
50	Are there any other challenges? Please specify.					